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100-kW METAL WIND TURBINE BLADE BASIC DATA, LOADS AND STRESS ANALYSIS

By
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June 1975

Lockheed-California Company
Burbank, California

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Lewis Research Center
Cleveland, Ohio 44135

Contract NAS 3-19235

and the
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
Division of Solar Energy
Federal Wind Energy Program

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16 Abstract
This report presents the results of a loads and stress analysis on the 60-ft-long metal blades for the ERDA-NASA 100-kW wind turbine. For the loading conditions examined, the metal blades are structurally adequate for use, within the normal operating range, as part of the wind turbine system.

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INTRODUCTION

Recent shortages in the supply of clean energy, coupled with increasing costs of fuel, have forced the nation to reassess all forms of energy, including wind power, to determine their practicality. The national wind energy program, which originated at the National Science Foundation and is now directed by the Energy Research and Development Administration (ERDA), includes research and development on the many applications and concepts of wind-energy systems.

As part of this program, the NASA Lewis Research Center was assigned the project responsibility of designing and constructing a wind turbine generator large enough to assess the technological requirements and engineering problems of large wind turbine generators. The 100-kW wind turbine was assembled, for the purpose of assessment, at the NASA-Lewis Plum Brook Station in Sandusky, Ohio. While the design and assembly of the wind turbine was conducted by NASA-Lewis, the detail design, analyses, fabrication, and test of three identical 60-foot-long metal blades were performed by the Lockheed Aircraft Corporation under NASA contract NAS 3-19235.

This report presents Lockheed's results of the blade loads analysis and contains the detailed stress analysis used to support the structural design. A preliminary investigation of wind shear and wind blockage due to the tower structure indicates that blade cyclic loads could be greater than the cyclic loads used in this analysis. For the blade loads used for this analysis, the metal blade can carry, without material yield, infrequent peak loads encountered during rapid changes in blade pitch angle at the rotor operating speed. The metal blade can also withstand an infinite number of cyclic loads during normal operation, as shown by this analysis. Recommendations for monitoring blade loads during operation are also specified.

REFERENCES

1. Bruhn - Analysis and Design of Flight Vehicle Structures.
2. S.M. - Lockheed Stress Memo Manual
3. MIL-HDBK 5B - Metallic Materials and Elements for Aerospace Vehicle Structures
4. NACA TN 2661 - A Summary of Diagonal Tension Part 1 - Methods of Analysis
5. LR 20159 Stress Memo Design Data
6. AFFDL-TR-69-42 - Stress Analysis Manual
7. NASA Specification No. 3-5722431
8. NASA Contract No. NAS 3-19235

SECTION 1.0

BASIC DATA

The blades built by Lockheed under Contract NAS3-19235 meet the following requirements:

- Rotor diameter of 125 ft
- Operating speed of 40 RPM
- Collective pitch range of blades, -3.5° to 92.5° at Station 75 radius
- 33.8° non-linear twist on each blade
- N.A.C.A. 23000 series airfoils
- All aluminum basic blade construction with a steel root fitting for attachment to the N.A.S.A. windmill hub
- Root attachment to conform to N.A.S.A. bolt size and patterns.

Geometry

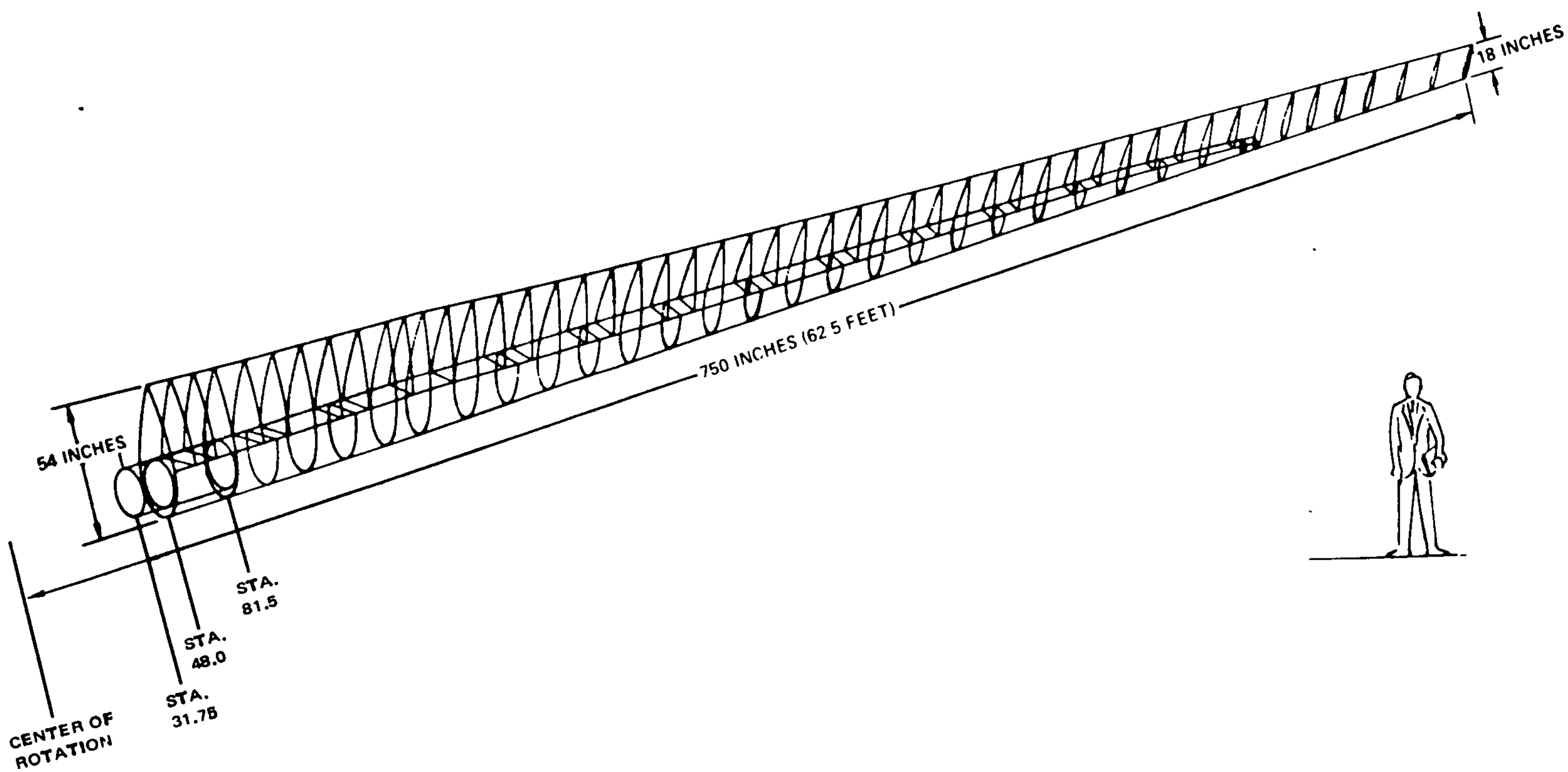
The overall external dimensions are shown in Figure 1.1.

A spanwise plot of blade chord, thickness ratio $\frac{t}{c}$, and blade angle are shown in Figures 1.2 to 1.5.

STAR category 44

100-kW WIND-TURBINE BLADE

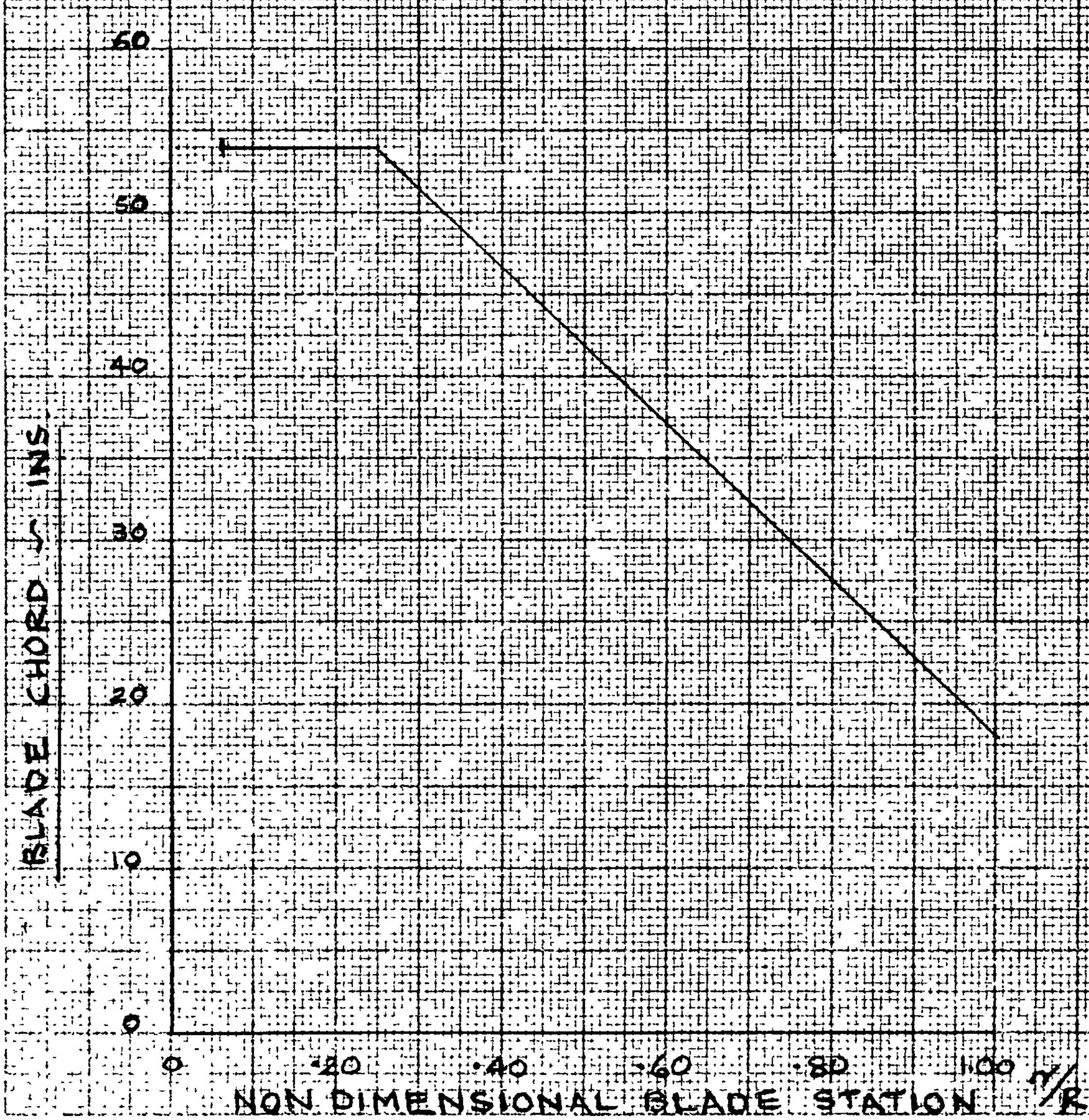
FIG 1·1 BLADE GEOMETRY



100-kW Wind-Turbine Blade

BLADE CHORD DISTRIBUTION

FIGURE 1.2

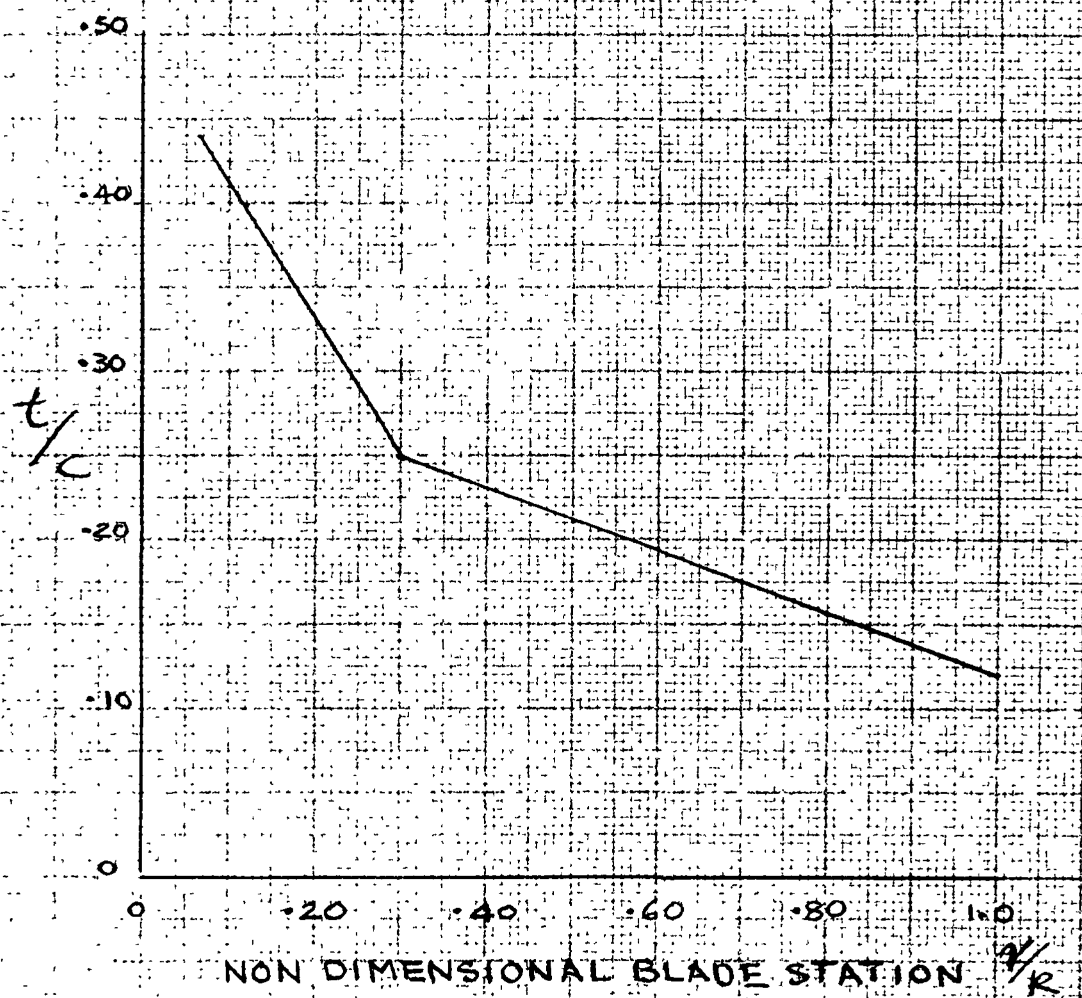


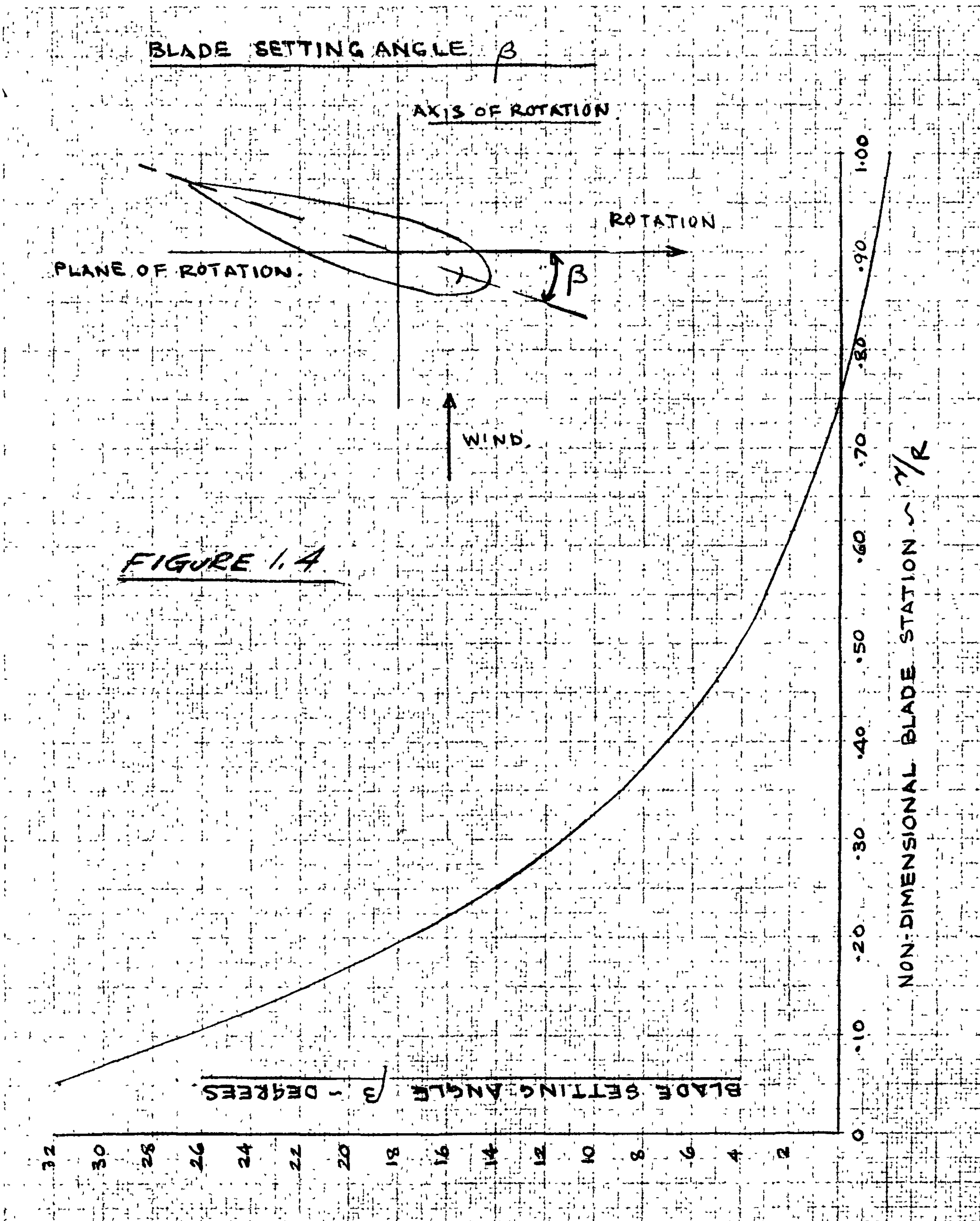
BLADE THICKNESS DISTRIBUTION

t = MAX THICKNESS

C = BLADE CHORD.

FIGURE 1.3




BLADE SETTING ANGLE β
AXIS OF ROTATION
ROTATION
PLANE OF ROTATION
β
WIND
FIGURE 1.4
BLADE SETTING ANGLE β - DEGREES
32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
NON-DIMENSIONAL BLADE STATION ~ r/R
.10 .20 .30 .40 .50 .60 .70 .80 .90 1.00

SECTION 2.0

WINDMILL BLADE LOADS

The structural design loads presented herein are the four (4) structural design conditions specified in Table I of Contract No. NAS3-19235 and is the basis on which the structural integrity of the blades is established. Additional loading conditions have been investigated, and are reported on, to illustrate the effects of 1) horizontal wind shear gradient and 2) tower shadow interference on cyclic bending loads.

ANALYSIS APPROACH

The rotor loads computer program (WINTUR) is utilized to define, in detail, the steady state and cyclic loads acting on the windmill blades. This computer program reflects a coupled response analytic method that yields spanwise and azimuthal distributions of airloads, bending moments and torsional moments depending on the operational mode selected.

In brief this computer program is a fully coupled aeroelastic blade loads analysis consisting of an aerodynamic performance/trim analysis of a rotor system that is coupled with the dynamic response of the blades. A relaxation type of iterative procedure is employed between the aerodynamics and blade responses to obtain a converged solution that is consistent with the blade mode shape. The aerodynamic portion of the program consists of expressions for rotor thrust, torque, shaft moments (pitch and roll), and shaft shear forces (lateral and longitudinal) utilizing C_ℓ, C_d, and C_m data vs, local blade angle of attack, section thickness, and Mach number. An iterative procedure permits one or all of the net rotor forces to be trimmed to describe the operational condition of the rotor in terms of the rotor control angles and/or attitude that is consistent with the response of the blades. The dynamic analysis portion of the program considers the blade response, in harmonic form, to the steady and unsteady airloads, Coriolis forces, gravitational effects and the structural coupling between the flapwise and chord-

wise bending moments due to collective pitch and local geometric twist angle. The structural model utilizes a finite element description that permits a detail definition of the rotor blade system. This description is unique in that two separate beams are defined to describe one integral rotor blade. The two beams are represented as 1) the feathering blade and cuff with provisions for up to 45 stations, and 2) the fixed hub which supports the blade and cuff with provisions for up to 30 stations. A total of 44 blade stations are used to represent the 100 kw windmill blades. This arrangement permits the determination and inclusion, in the net response of the blade, of 1) feather bearing radial forces, 2) feather bearing support elasticity, and 3) kick shear forces resulting from the blade retention mechanism. A quasi-coupled elastic torsion analysis is made where extensive use is made of the output from the basic coupled analysis. The elastic twist angles, as determined in the torsion analysis, are reflected in the aerodynamics of the successive aero-structures cycle in the relaxation process.

Among the many program operating options provided there is one that permits the application of an arbitrary spanwise airloading distribution to the blade structure at any discrete exciting frequency that is an integer multiple of the rotor speed. It is this option that is used to determine the aero-elastic characteristics of the blades for the specified air loads of this concept.

The sign convention incorporated into the WINTUR computer program and used in this section of the report is shown in Figure 2.1.

WINDMILL BLADE DESIGN LOADS

Blade loads, natural frequencies and mode shapes presented in this section reflect the blade mass and stiffness distributions and related data given in Section 3.0 of this report.

Rotating natural frequencies and mode shapes are computed using a subset of the "WINTUR" program and utilize the same structural description and inputs as that employed in the blade loads analysis. This approach insures the computation of blade frequencies that are directly compatible with computed blade loads.

Natural frequencies for the cantilever blades were computed at various rotor speeds from zero to 50 RPM and at pitch settings, defined at the 3/4 blade radius, of 10°, 0°, and -10°. The result of these calculations are presented in Figure 2-2 and shows that for the normal operating speed of 40 RPM there is adequate separation of the blade frequencies from the aerodynamic excitations at the integer multiples of the rotor speed, nP. Also, the frequency spectrum shows that there is a negligible variation in the frequencies within the blade pitch settings investigated. Blade mode shapes associated with the frequencies at the nominal rotor speed of 40 RPM and zero degree blade pitch setting are shown in Figures 2-3 through 2-5 for the first three natural frequencies. The first and lowest mode is 2.76P and it is defined as the first flapping mode where the primary blade motion is normal to the plane of rotation. The second mode is 3.62P and is defined as the first inplane mode with primary blade motions in the rotational plane. The third mode is at 7.57P and shows that the primary motion is again normal to the plane of rotation and it is called the second flapping mode.

The structural integrity of the windmill blades is based on the four (4) spanwise aerodynamic loading conditions as stipulated by Contract No. NAS3-19235 and shown on Figures 6 through Figure 9 of the contract. The four design conditions are summarized in Table 2.1.

TABLE 2.1

Design Condition as Specified by Contract

Case No.	Blade Pitch Setting @ 3/4 Radius	Rotor Speed RPM	Wind Velocity MPH	Figure # in Contract for Aerodynamic Load Distribution
1	0°	40.	18.	6
2	0°	40.	60.	7
3	-90°	40.	18.	8
4	0°	40.	0.	9

For each of the loading cases in Table 2.1 steady and cyclic, 1P, blade loads were computed using the special option capability of the "WINTUR" program as discussed earlier in the analysis approach section. This computation process uses the specified airloads as inputs to obtain the steady state blade bending loads and elastic characteristics. The gravitational effects, due to the spanwise blade mass distribution, is used to define the cyclic blade bending loads and elastic characteristics.

The influence of inplane Coriolis accelerations on cyclic bending loads are obtained independently and superimposed to those due to the gravitational effects. In terms of prime factors the cyclic, 1P, blade root moments, due to Coriolis force, can be expressed as follows:

$$q_o = 2 I_b \Omega^2 a_o a_1 \text{ SIN } \Psi \qquad (1)$$

where:

q_o = blade root moment, in.-lb.

I_b = mass inertia of one blade, slug - in.^{2} (571100 slug - in.^{2})

= rotation speed of windmill, rad/sec. (4.189 rad/sec = 40 RPM)

Ψ = azimuth position - radians

a_o = effective blade cone angle referenced to 3/4R - radians

a_1 = effective "1P" blade flapping angle referenced to 3/4R, - radians

Based on the elastic characteristic obtained from the "WINTUR" program and carrying through with the required substitutions above the blade root inplane moments, as well as the effective cone and 1P flapping angles, are presented in Table 2.2 for the specified loading conditions.

The distribution of the cyclic inplane blade root moment along the span of the blade is accomplished by using a predetermined 1P bending distribution curve. The net spanwise distribution of the cyclic chordwise bending moment is the sum of that due to gravity effects and those due to Coriolis acceleration. Comparing the relative magnitude of the cyclic chordwise bending moments of

of Figure 2-10 with the blade root cyclic moments in Table 2.2, for cases 1, 2, and 4, it can be seen that Coriolis accelerations have a very negligible effect on the net 1/2 (P-P) cylcic chordwise bending moments. This also holds true for case 3 where the cyclic beamwise bending moment of Figure 2-11 must be compared to the cyclic blade root moment due to Coriolis effects. In view of this, Figure 2-10 presents the net cyclic bending loads for cases 1, 2, and 4 and Figure 2-11 those for case 3.

TABLE 2.2

Coriolis Blade Root Inplane Bending Moment

Case No.	a_o (rad.)	a_1 (rad.)	K_c $q_o\Psi = K_c \, \mathrm{SIN}\, \Psi$; in.lb.
1	0.112759	-.000608	-1374
2	0.139723	-.000608	-1703
3	0.112951	-.000624	+1413
4	0.103692	-.000608	-1264

The spanwise distribution of the steady state beamwise and chordwise bending moments and inplane and axial shears for the four loading conditions are shown on Figures 2.6 through Figure 2.9. The centrifugal force distribution along the blade span for the nominal rotor speed of 40 RPM is shown on Figure 2.12.

EXPOSITORY ANALYSIS

Detail consideration must be given to both the static and fatigue strength level loads anticipated during the life of the blade in order to achieve a windmill blade that is reliable. This entails the investigation of loading conditions that reflect the operational environment to which the blades will be exposed. The following tentative list of conditions should be investigated in addition to the four presented in Table 2.1.

1. Rotor yaw angle with respect to wind velocity.
2. Rotor yaw rates
3. Combinations of rotor yaw angle, yaw rates and yaw direction
4. Rotor speed variations
5. Wind speed variations
6. Blade pitch setting variation
7. Ground wind velocity shear profile
8. Windmill tower shadow interference
9. Gusts
10. Start-stop cycles
11. Non-rotating blade loads in an extreme wind environment
12. Various combinations of the above operational modes

A cursory investigation was conducted pertaining to some of the above loading conditions to demonstrate their effect on cyclic blade loads and are reported on for comparison purposes only. The analysis utilized the full capabilities of the "WINTUR" computer program discussed earlier.

Tower shadow interference effects are included in "WINTUR" by considering the tower to have a retardation effect on the free stream velocity over a sector of the windmill disk as depicted in Figure 2.13. This is accomplished by assigning an arbitrary value to, $\bar{\varphi}$, the sector over which the flow through wind is retarded and, K_V, the percentage of wind velocity retardation.

The effect of tower shadow is to induce a "1P" pulse to each blade as it passes the tower. The pulse contains higher frequency blade responses whose magnitudes are a function of sector size and degree of tower interference.

A limited investigation was conducted to determine the influence of sector size and various tower interference factors on cyclic blade bending moments and tower loads using the design condition described by Case 1 of Table 2.1 as the baseline. The combination of parameters examined are given in Table 2.3.

TABLE 2.3

Tower Shadow Interference Parameters

Legend	Sector Size $\overline{\Psi}$	Percent of Interference K_v
Baseline	0°	0.0
	60°	7.4
	60°	25.0
	18°	25.0

The cyclic 1/2 (P-P) blade bending moments of this study are shown in Figures 2.14 and 2.15 and the tower loads are given in Table 2.4 in harmonic form. The data shows that there is a pronounced increase, from the baseline case, of the beamwise cyclic bending moments and a negligible increase of the chordwise bending moments for the parameters investigated. It should be noted that there is a very dramatic increase of the beamwise cyclic bending moments over the span of the blade. For example the cyclic beamwise bending (.5 span) moment shows an increase of 1500% over the baseline data for the worst assumption. This indicates that the tower shadow effect could have a significant effect on fatigue loading. The actual increase would depend on its true severity.

The effect of tower shadow interference on tower loads is given in Table 2.4 and shows that the primary influence is on shaft bending moments in both the yaw and pitch directions. Steady shaft moments show an appreciable increase over the baseline case when tower shadow effects are included and that higher frequency shaft moments, "4P", are probably more dependent on the interference factor than sector size.

Wind shear gradients, with respect to altitude, can be approximated by the simple power expression of reference 2.1. In simple terms the expression given is:

$$V_v \propto H^n \tag{2}$$

Equation (2) simply states that the horizontal wind velocity, V_v, is proportional to altitude H raised to the power n. The vertical wind velocity profile suggested by equation (2) reflects the earth's boundary layer effect and is dependent on the earth's surface roughness characteristics which are included in the exponent n. It should be noted that reference 2.1 points out that the vertical change in wind direction is negligible within the lowest 300 feet of altitude if the overall airflow is strong and the site free of obstructions.

Wind shear is implemented in the "WINTUR" computer program by adjusting equation (2) to reflect the nominal wind velocity V_v at the rotor shaft axis altitude H_o as depicted in Figure 2.16 and then defining the incremental wind velocity variation (ΔV_{v_H}) over the rotor disk area. The incremental wind velocity with respect to the nominal wind velocity can be expressed as follows:

$$\Delta V_{v_H} = V_v \left[\left(1 + \frac{r}{H_o} \text{ SIN } \quad \right)^n - 1 \right] K_w \tag{3}$$

Where:

ΔV_{v_H}	=	Incremental change in wind velocity at altitude, feet per second
V_v	=	Nominal wind velocity, feet per second
H_o	=	Elevation of rotor shaft axis, feet
ψ	=	Azimuth position, degrees
r	=	Local blade radius, feet
n	=	Exponent describing earth's surface roughness
K_w	=	Factor, normally equal to 1.0 when n is less than 1.0. If n is equal to 1.0 then K_w describes a linear variation of wind shear gradient

A linear variation of wind shear was examined having a gradient of K_w equal to 0.125 using the design condition described by case 1 of Table 2.1 as the baseline. The cycle blade bending moment distributions of this investigation, with and without the effects of tower shadow interference, are shown in Figures 2.17 and 2.18 and the corresponding tower loads are given in Table 2.4. The results again show that there is an appreciable increase in the beamwise cyclic bending moments from the baseline case and a negligible effect on the chordwise bending moment distribution. Two blade stations are examined as a function of rotor azimuthal position and shown in Figure 2.19 to further illustrate the effects of wind shear and tower interference on cyclic beamwise bending moments. The results show that the influence of higher frequency loads on the overall content of 1/2 (P-P) cyclic beamwise moments is more predominant outboard along the blade span. Tower loads reflecting the influence of linear wind shear is given in Table 2.4 and shows that only steady and 2P tower loads are developed. This demonstrates that only 1P blade airloads are generated by a linear wind shear representation. However, it should be noted that if n were assigned values other than 1.0 such as 1/5 for values of V_V between -5 and -35 mph, as suggested by some literature, and letting K_w = 1.0, then higher frequency airloads will occur. This will then result in higher frequency blade bending and tower loads.

In addition to the tower loads due to wind shear and tower shadow, Table 2.4 also includes data for the following conditions:

- Four design conditions specified by contract
- Limited excursion of blade pitch angle
- Limited combination of yaw rate and yawed wind direction with respect to the drive shaft

It should be noted that the largest steady and 2P shaft moments reported are for the combined yaw rate and yawed wind velocity condition. In the event of a failure mode where the yaw mechanism fails, such as may occur when: 1) the rotor is unable to yaw resulting in large yaw wind direction angles, 2) the rotor experiences inadvertent large yaw rates, and 3) the combination of

1 and 2, then much larger tower loads can be expected to be developed and must be considered in the structural design envelope.

CONCLUSIONS

The wind turbine blades were designed to the aeroelastic loads developed for the four design conditions as specified by contract. Additional loading conditions were explored to ascertain the influence of various parameters on design loads that may affect the life and reliability of the blades and/or tower. The following conclusions were arrived at:

1. Tower shadow interference has a pronounced effect on the magnitude of cyclic blade bending moments and tower loads depending on sector size and/or the degree of free stream wind velocity retardation over the rotor sector.

2. Cyclic beamwise bending moments due to tower shadow were shown to increase the baseline cyclic moments used for fatigue analysis. The increase is most significant in the mid span. This loading should be further investigated relative to its effect on fatigue life.

3. Tower shadow tends to reduce the energy extracted from the wind, for a given blade pitch setting, resulting in a less efficient wind energy generator when compared to analysis that ignores the tower.

4. Horizontal ground wind shear results in primarily 1P blade loads and steady and 2P tower loads for a linear wind shear gradient. However, a non-linear wind shear would result in higher frequency blade and tower loads in addition to those experienced for a linear wind shear gradient. This results in larger cyclic loads and will adversely effect the wind energy system.

5. Failure of the yaw control (unable to adjust to the wind direction and/or excess yaw rates) will produce relatively large cyclic blade and tower loads effecting the life of the wind energy system.

The conclusions presented are based on a limited examination of some of the design conditions listed in this section of the report. Based on the cursory analysis presented, the fatigue loading could be significantly increased by tower shadow effects. These effects have not been included in the baseline data.

LIST OF REFERENCES

2.1 Valley, Shea L., 1965, "HANDBOOK OF GEOPHYSICS AND SPACE ENVIRONMENTS," Air Force Cambridge Research Laboratories, McGraw-Hill Book Company, Inc.

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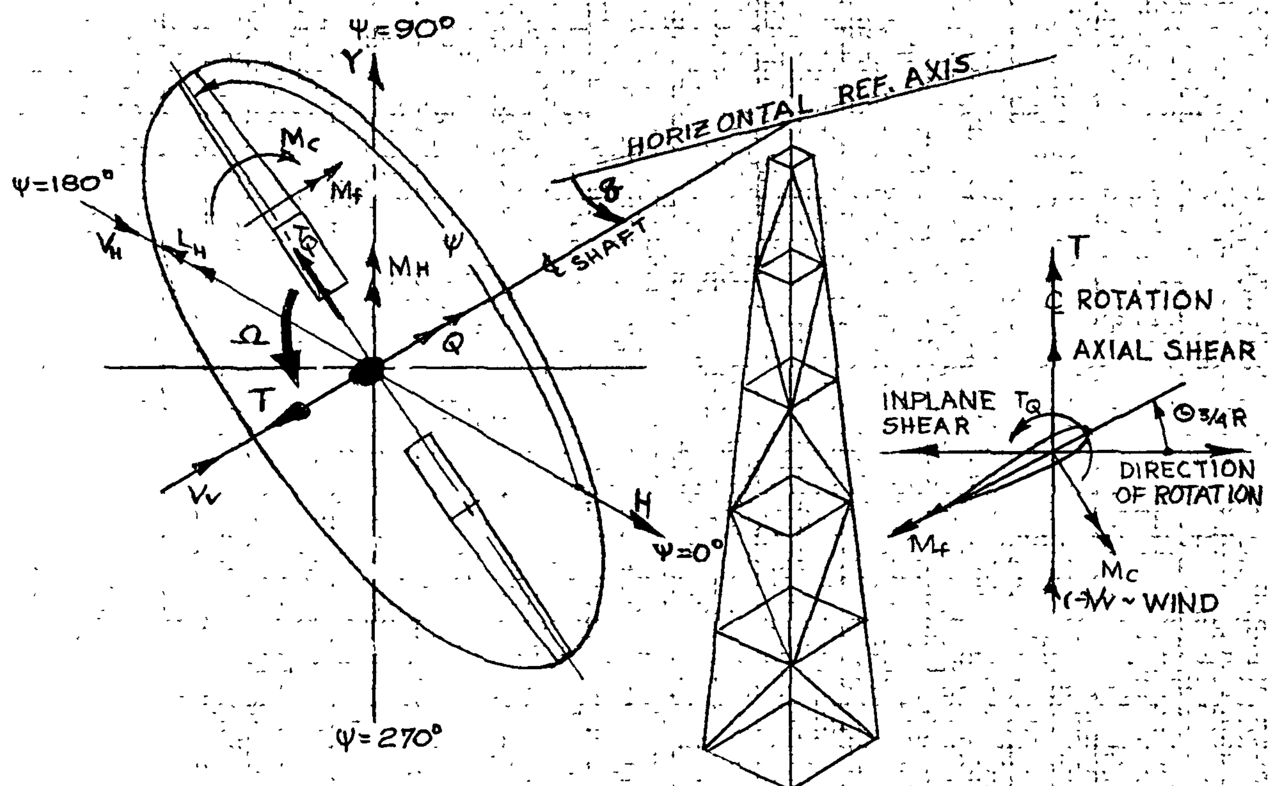
GAIDELIS

WINDMILL BLADE/TOWER LOADS SIGN CONVENTION
"WINTUR" PROGRAM



NOTE: RIGHT HAND RULE APPLIES

NOTATION:

- T ~ SHAFT AXIAL LOAD ~ POUNDS
- Y ~ SHAFT NORMAL FORCE (VERTICAL) ~ POUNDS
- H ~ SHAFT NORMAL FORCE (YAW) ~ POUNDS
- Q ~ SHAFT TORQUE ~ INCH POUNDS
- M_H ~ SHAFT YAW MOMENT ~ INCH POUNDS
- L_H ~ SHAFT PITCH MOMENT ~ INCH POUNDS
- V_H ~ VELOCITY COMPONENT NORMAL TO SHAFT AXIS ~ FT/SEC.
- V_V ~ VELOCITY COMPONENT PARALLEL TO SHAFT AXIS ~ FT/SEC. (NEGATIVE FOR WINDMILL)
- γ ~ ROTOR YAW RATE ~ RAD/SEC
- Ω ~ WINDMILL ROTATIONAL SPEED ~ RAD/SEC.
- Ψ ~ AZIMTHAL POSITION OF WINDMILL BLADE ~ DEG.
- $\Theta_{3/4R}$ ~ BLADE PITCH AT THREE QUARTER BLADE RADIUS ~ DEG.
- M_f ~ BLADE BEAMWISE BENDING MOMENT ~ INCH POUNDS
- M_c ~ BLADE CHORDWISE BENDING MOMENT ~ INCH POUNDS
- T_Q ~ BLADE TORSION MOMENT ~ INCH POUNDS

FIGURE 2.1

100 KW WINDMILL BLADE COUPLED FREQUENCY SPECTRUM

CANTILEVER MODE

$-10^\circ \geq \theta_{3/4R} \leq 10^\circ$

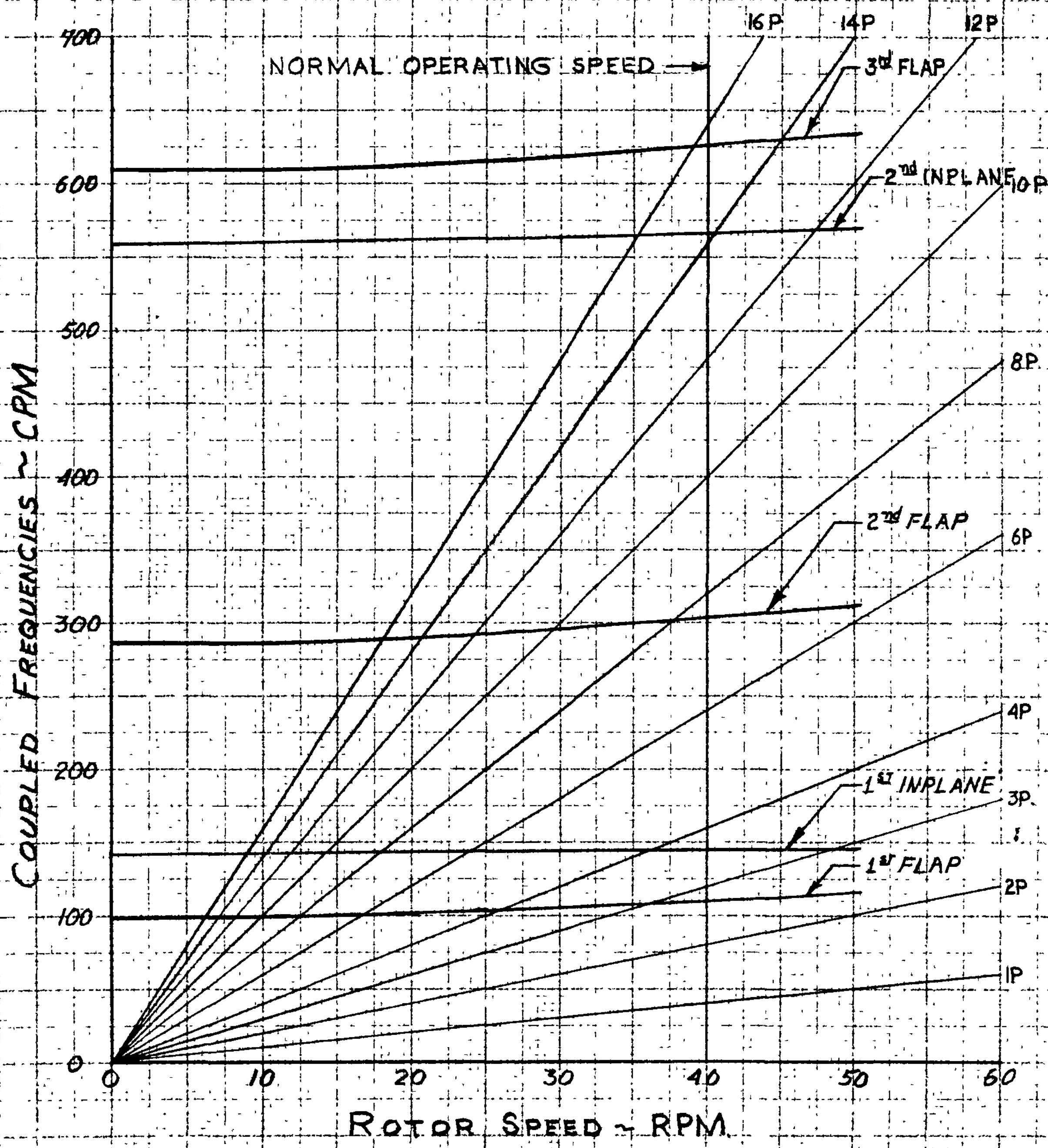


FIGURE 2.2

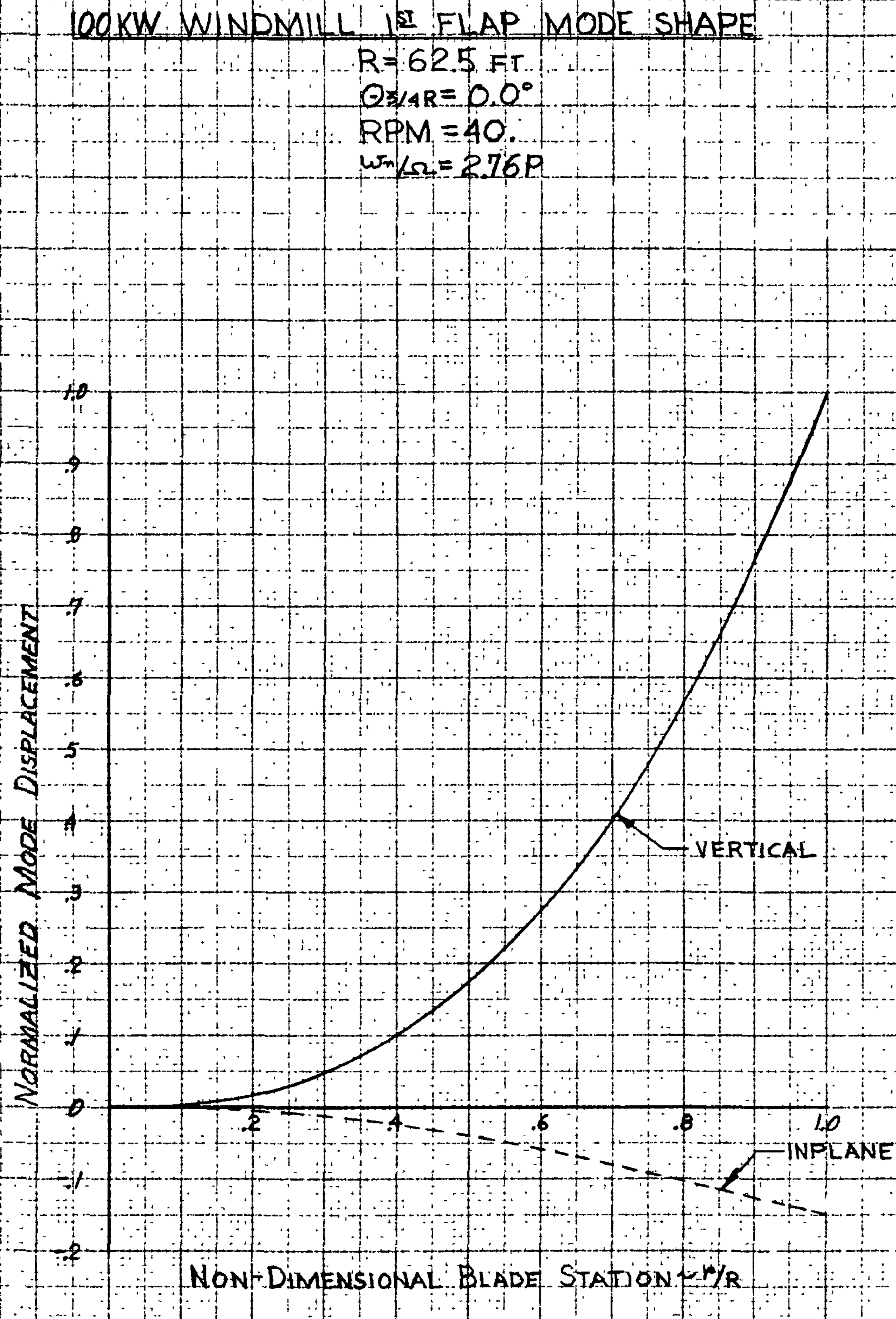

100KW WINDMILL 1ST FLAP MODE SHAPE
R = 62.5 FT
$\Theta_{3/4R} = 0.0°$
RPM = 40.
$\omega_n/\Omega = 2.76P$
NORMALIZED MODE DISPLACEMENT
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
-.1
-.2
.2
.4
.6
.8
1.0
VERTICAL
INPLANE
NON-DIMENSIONAL BLADE STATION ~ r/R

FIGURE 2.3

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

100KW WINDMILL 1ST INPLANE MODE SHAPE

R = 62.5 FT
$\Theta_{3/4R} = 0.0°$
RPM = 40.
$\omega_n/\Omega = 3.62P$

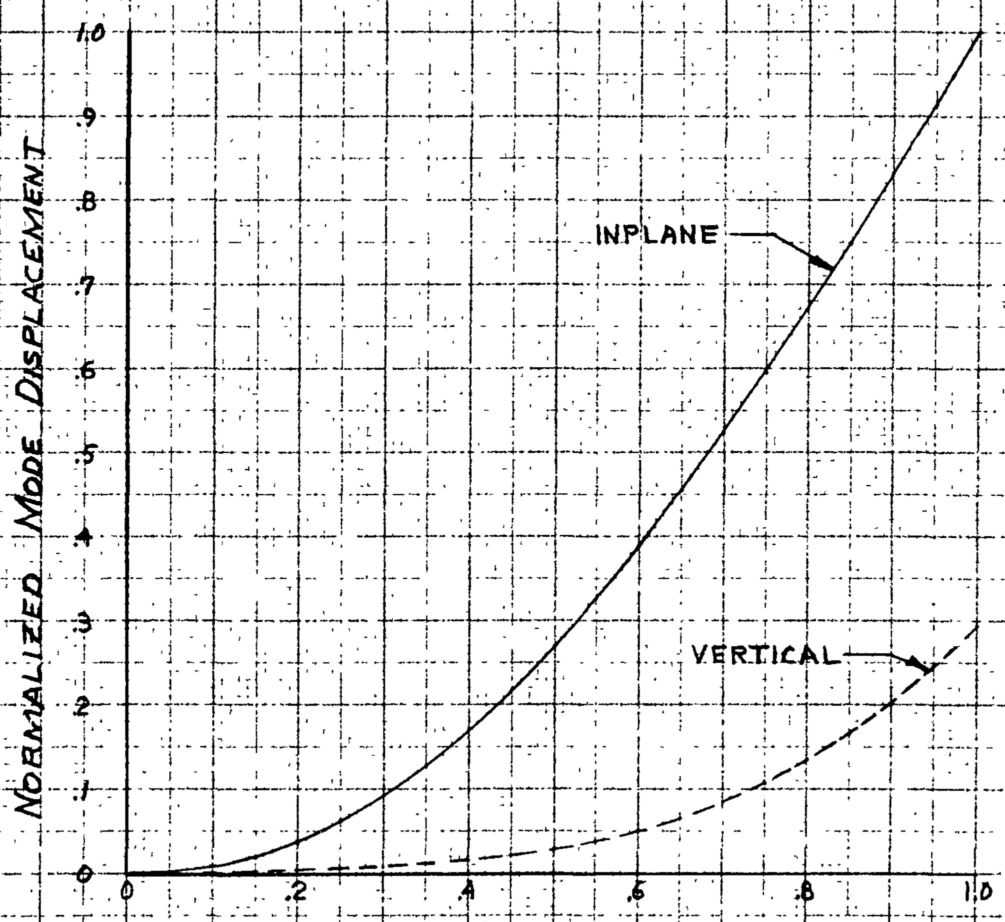


FIGURE 2.4

100 KW WINDMILL 2nd FLAP MODE SHAPE

R = 62.5 FT
$\theta_{3/4R} = 0.0°$
RPM = 40.
$\omega_n/\Omega = 7.57P$

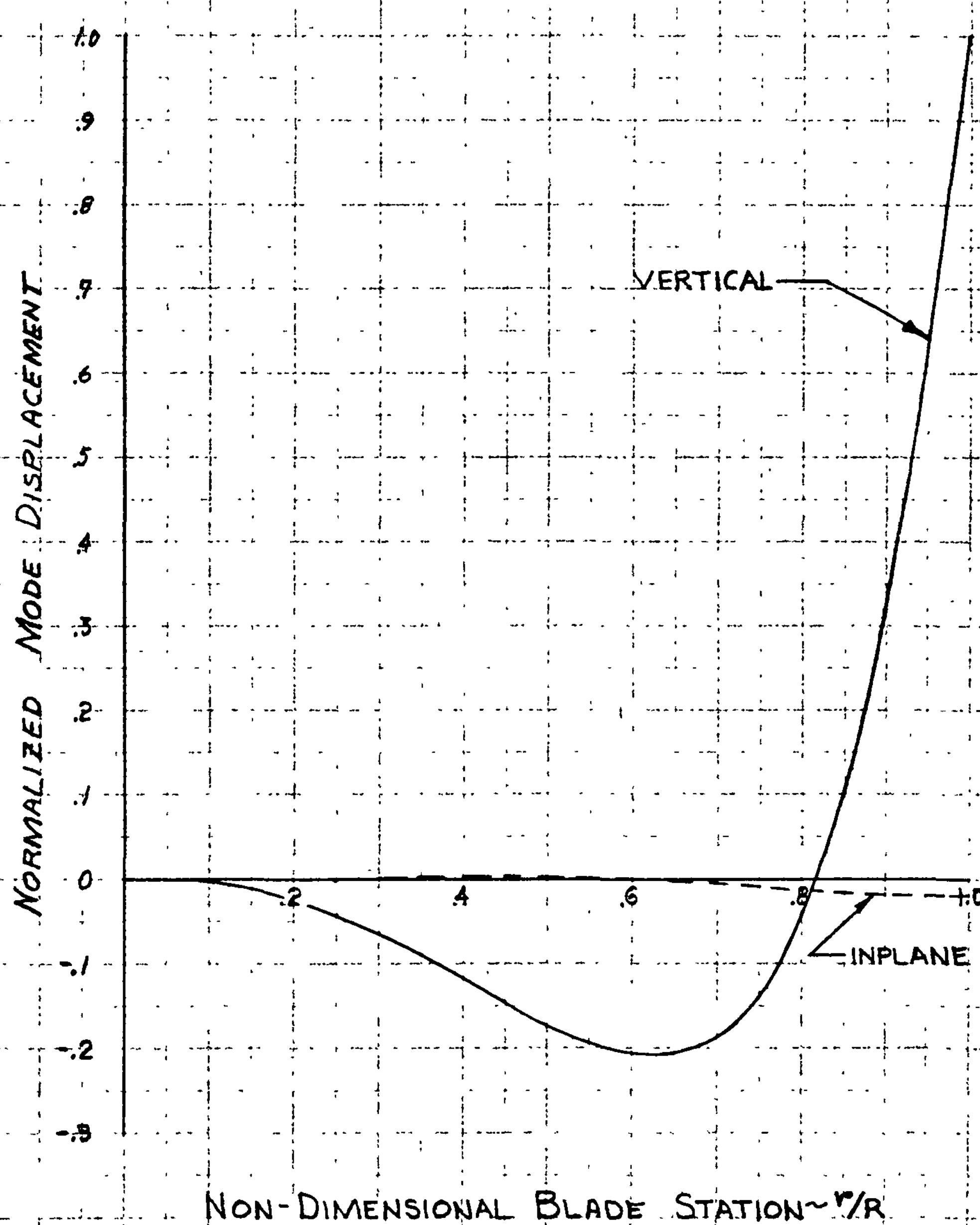


FIGURE 2.5

100KW WINDMILL BLADE LOADS
CASE 1 ~ MEAN LOADS

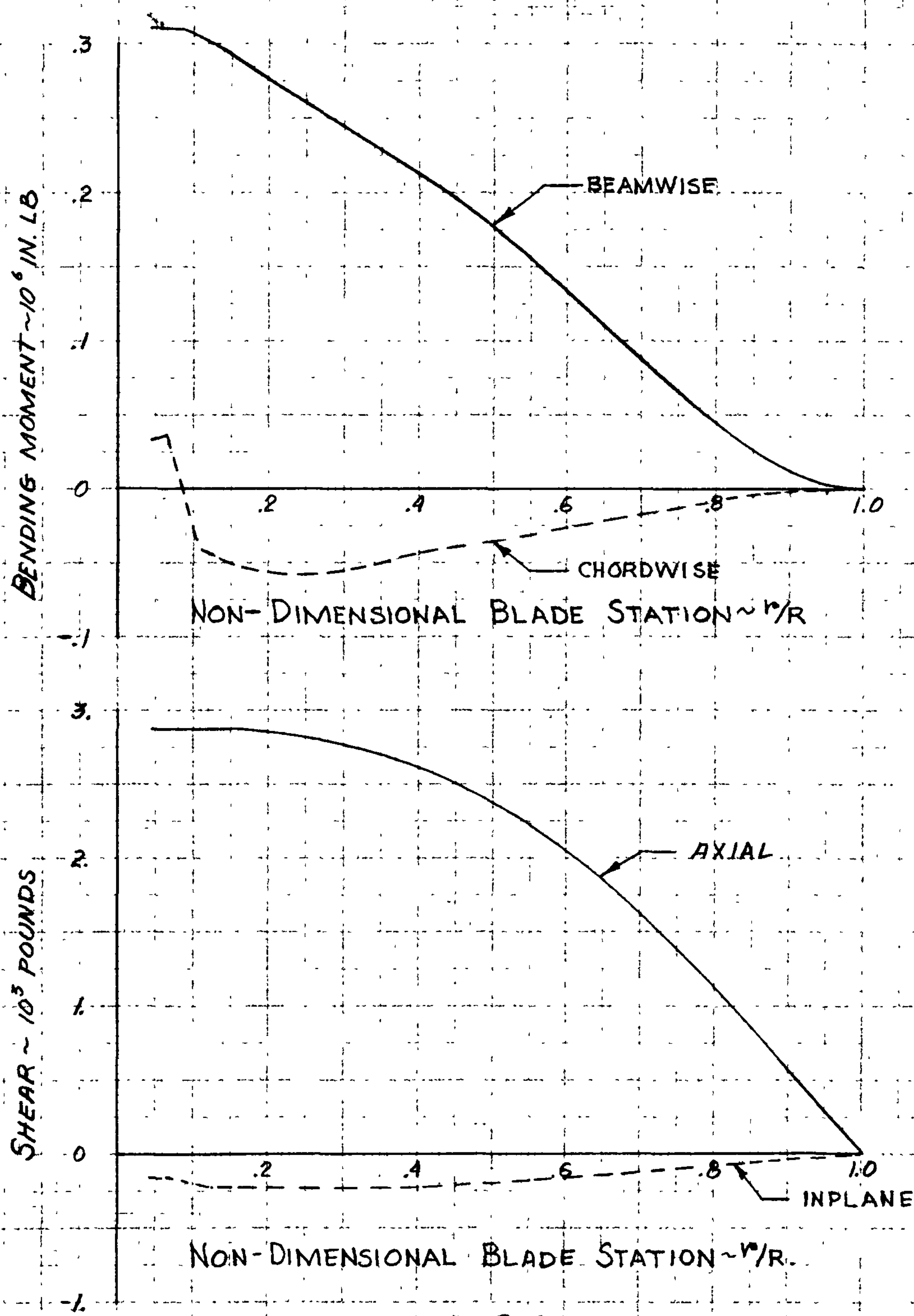


FIGURE 2.6

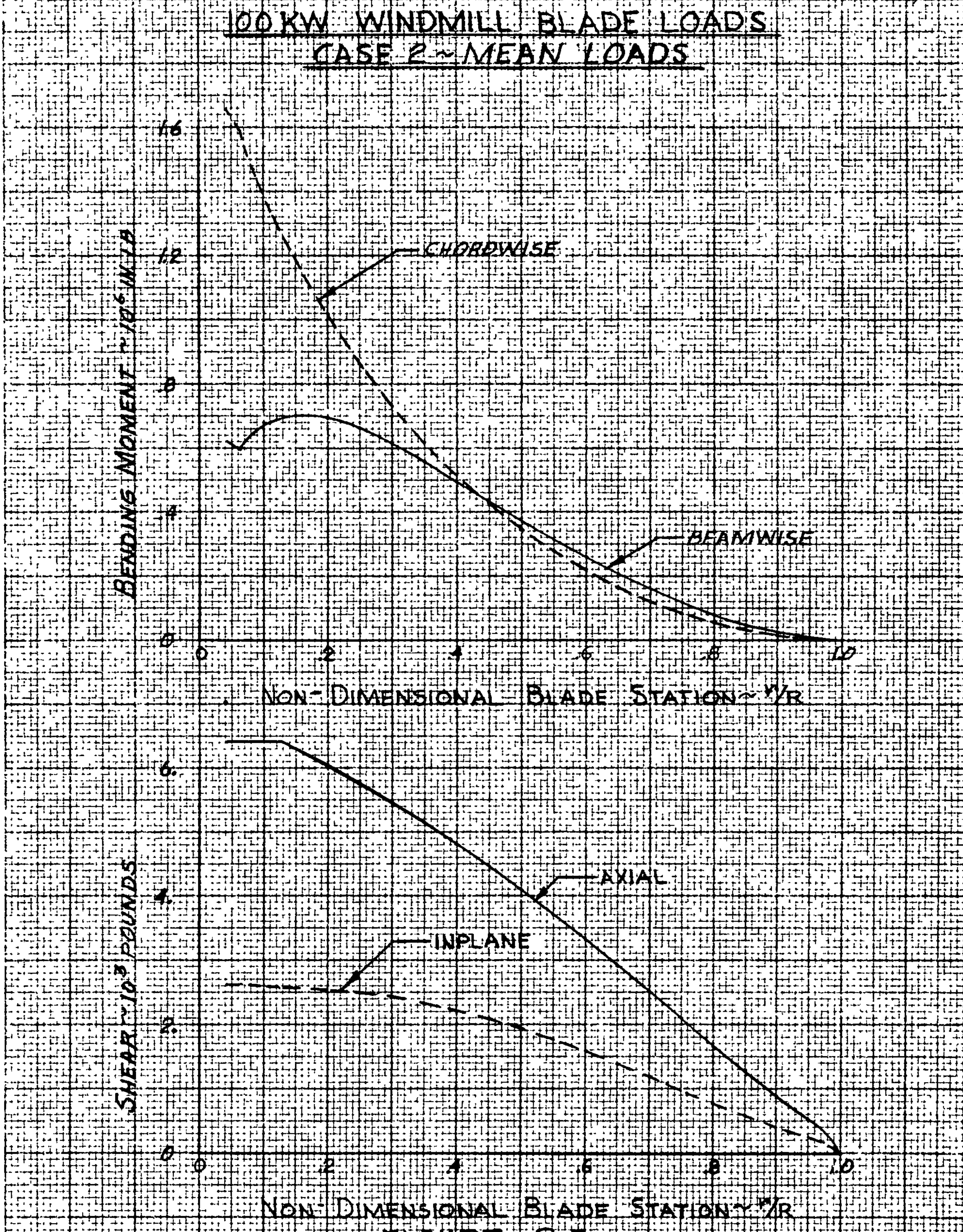

100 KW WINDMILL BLADE LOADS
CASE 2 ~ MEAN LOADS
BENDING MOMENT ~ 10⁶ IN.LB
1.6
1.2
.8
.4
0
CHORDWISE
BEAMWISE
0
.2
.4
.6
.8
1.0
NON-DIMENSIONAL BLADE STATION ~ r/R
SHEAR ~ 10³ POUNDS
6.
4.
2.
0
AXIAL
INPLANE
0
.2
.4
.6
.8
1.0
NON-DIMENSIONAL BLADE STATION ~ r/R

FIGURE 2.7

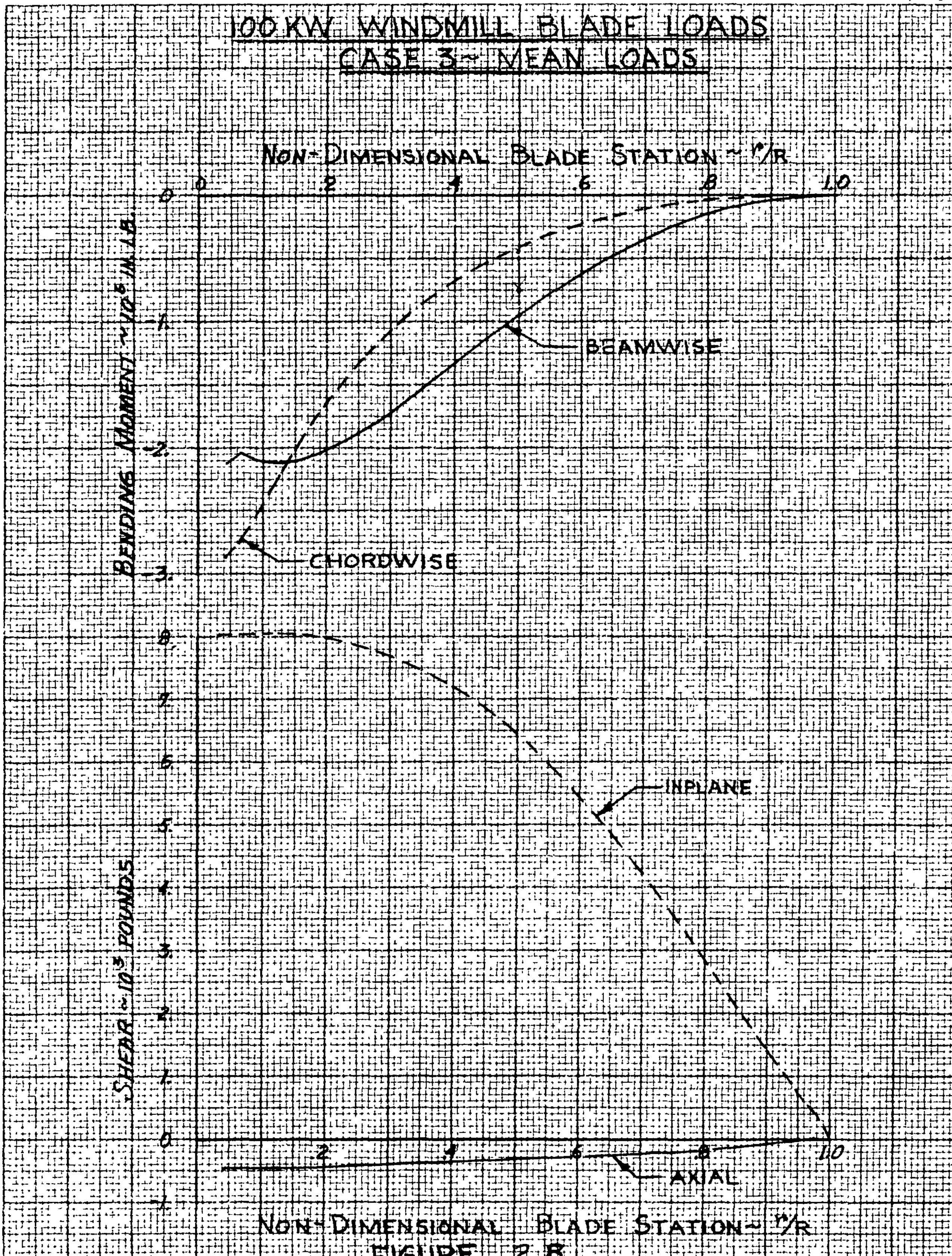

100 KW WINDMILL BLADE LOADS
CASE 3 ~ MEAN LOADS
NON-DIMENSIONAL BLADE STATION ~ r/R
0
.2
.4
.6
.8
1.0
BENDING MOMENT ~ 10^6 IN.LB.
-1.
-2.
-3.
BEAMWISE
CHORDWISE
SHEAR ~ 10^3 POUNDS
8.
7.
6.
5.
4.
3.
2.
1.
-1.
INPLANE
AXIAL
NON-DIMENSIONAL BLADE STATION ~ r/R

FIGURE 2.8

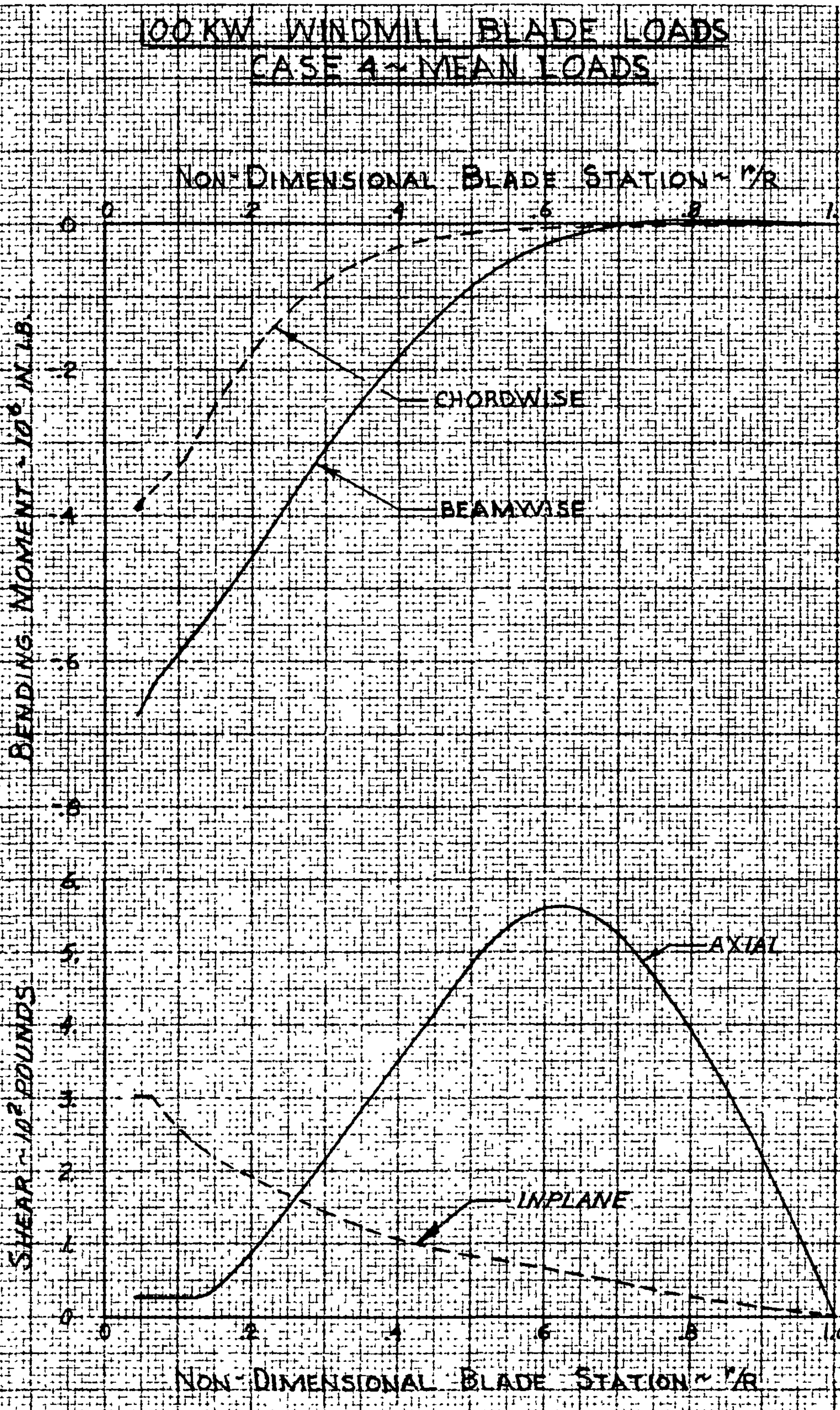

100 KW WINDMILL BLADE LOADS
CASE 4 ~ MEAN LOADS
NON-DIMENSIONAL BLADE STATION ~ r/R
0
.2
.4
.6
.8
1.0
BENDING MOMENT ~ 10^6 IN.LB.
0
-2
-4
-6
-8
CHORDWISE
BEAMWISE
SHEAR ~ 10^2 POUNDS
6
5
4
3
2
1
0
AXIAL
INPLANE
NON-DIMENSIONAL BLADE STATION ~ r/R

FIGURE 2.9

100 KW WINDMILL BLADE LOADS
CASE 1, 2 AND 4 ~ CYCLIC LOADS

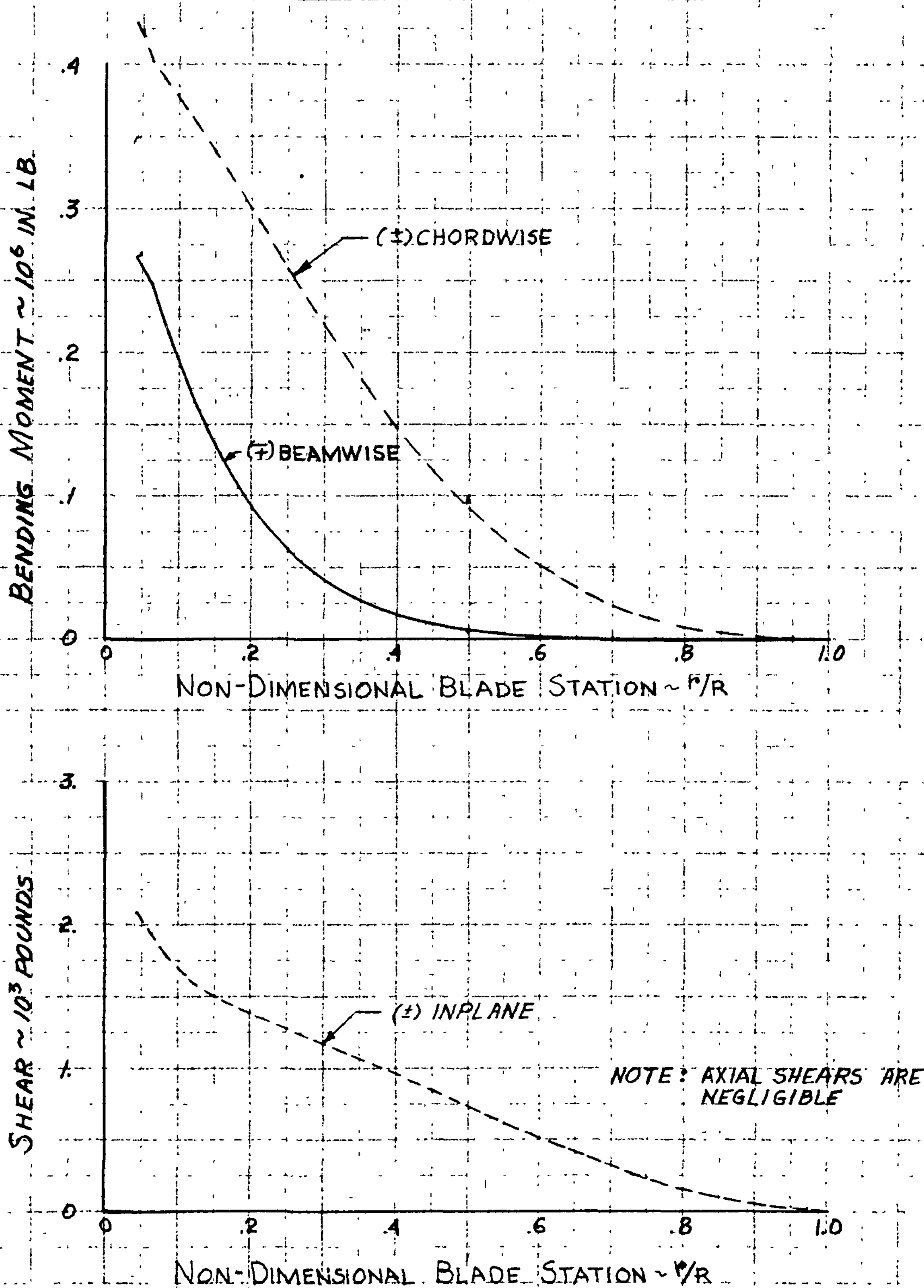


FIGURE 2.10

100 KW WINDMILL BLADE LOADS
CASE 3 ~ CYCLIC LOADS

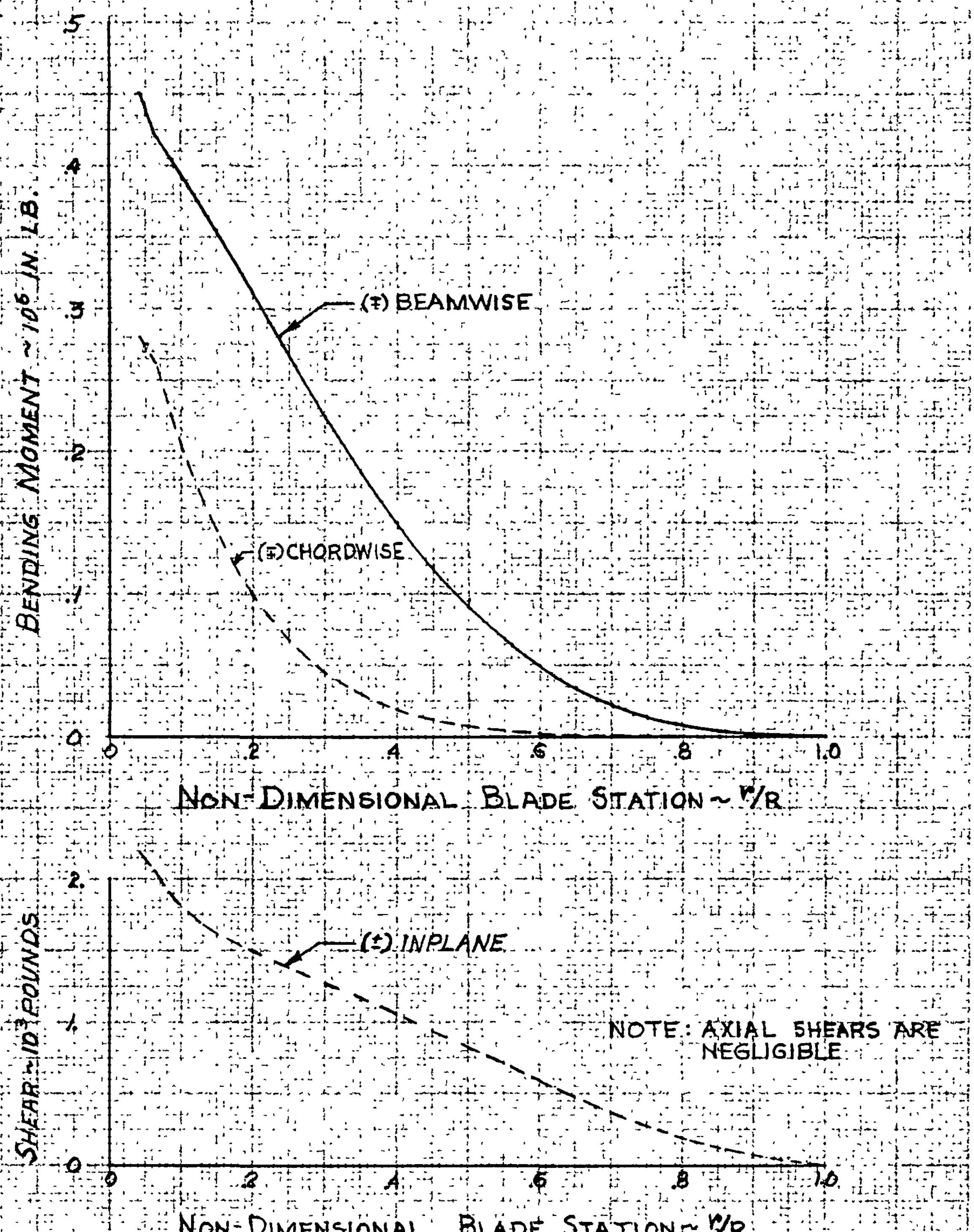


FIGURE 2.14

100 KW WINDMILL BLADE CENTRIFUGAL FORCE
RPM=40
R=62.5 FT.

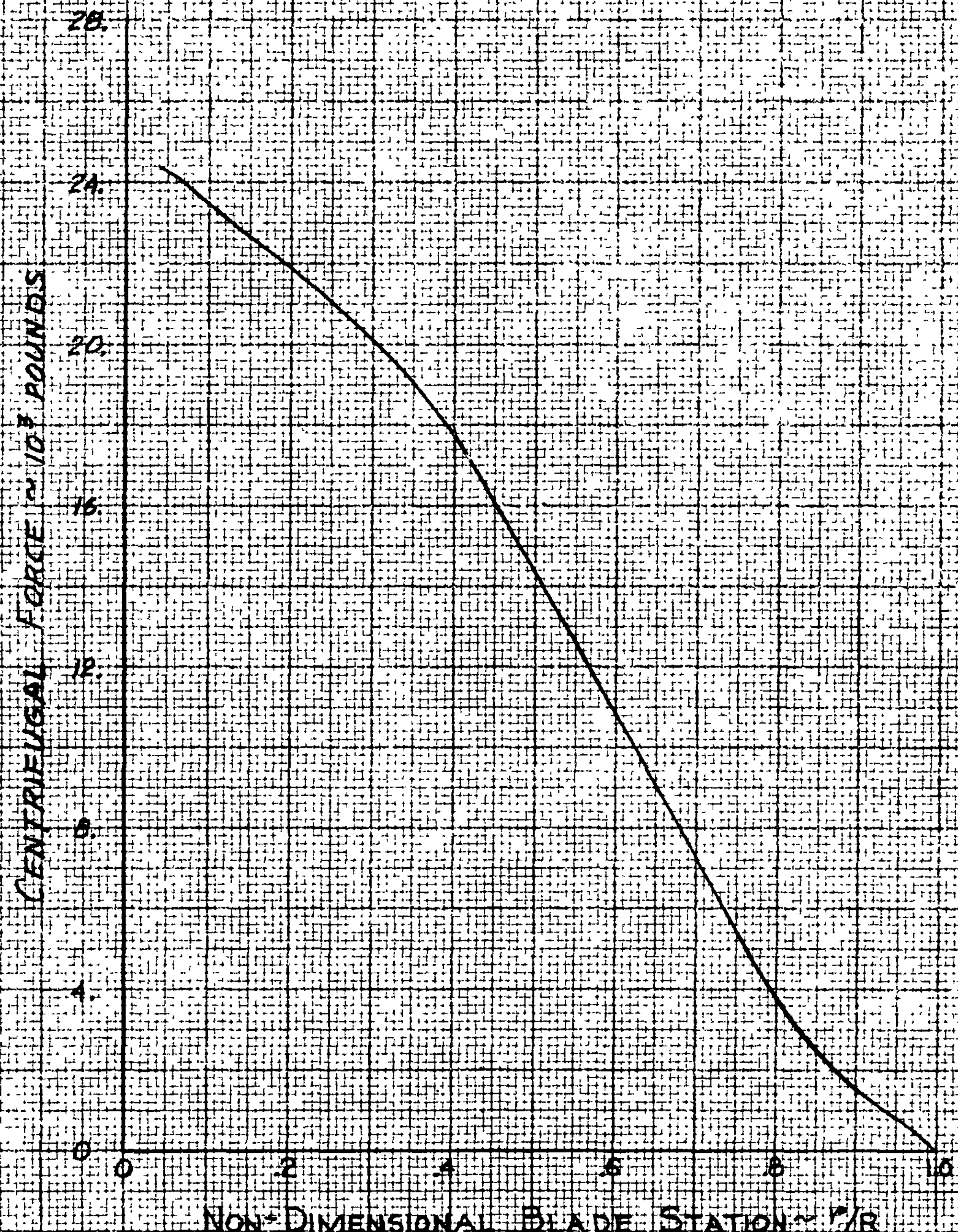
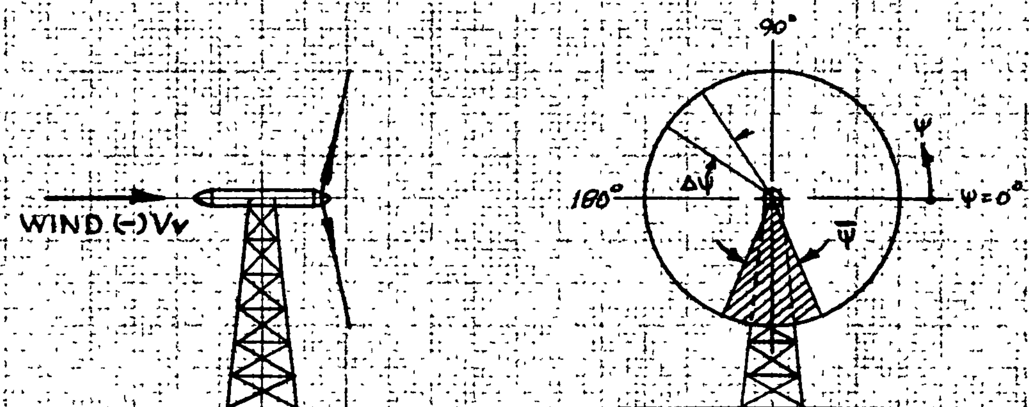


FIGURE 2.12

TOWER SHADOW INTERFERENCE REPRESENTATION



$\bar{\Psi}$ = SECTOR OVER WHICH THE FLOW THROUGH WIND VELOCITY IS RETARDED

K_V = PERCENTAGE OF WIND VELOCITY RETARDATION

$\Delta\psi$ = AZIMUTHAL SECTOR WIDTH CONSIDERED IN "WINTUR" ANALYSIS

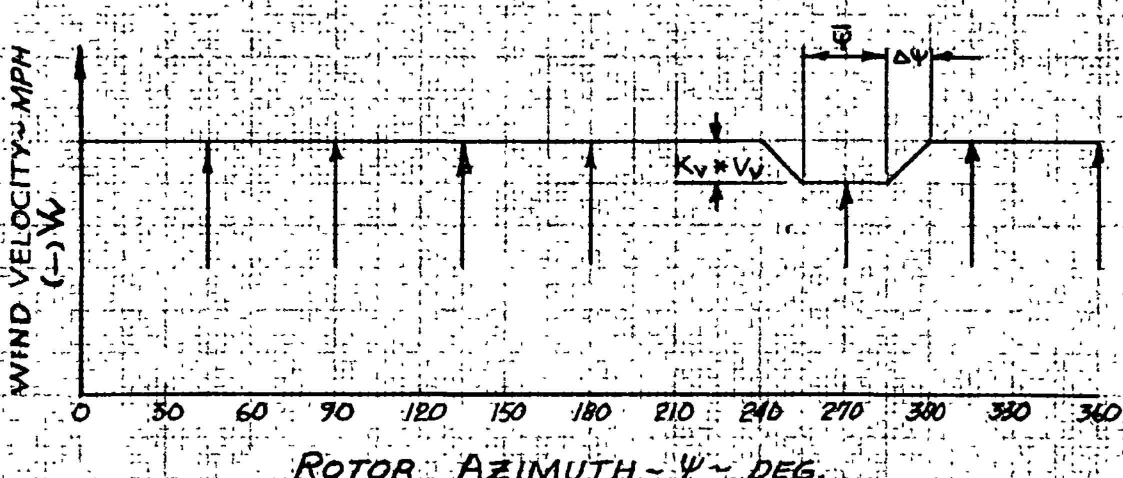


FIGURE 2.13

WIND TURBINE CYCLIC BLADE LOADS COMPARISON
EFFECTS OF TOWER SHADOW INTERFERENCE
BEAMWISE BENDING MOMENT

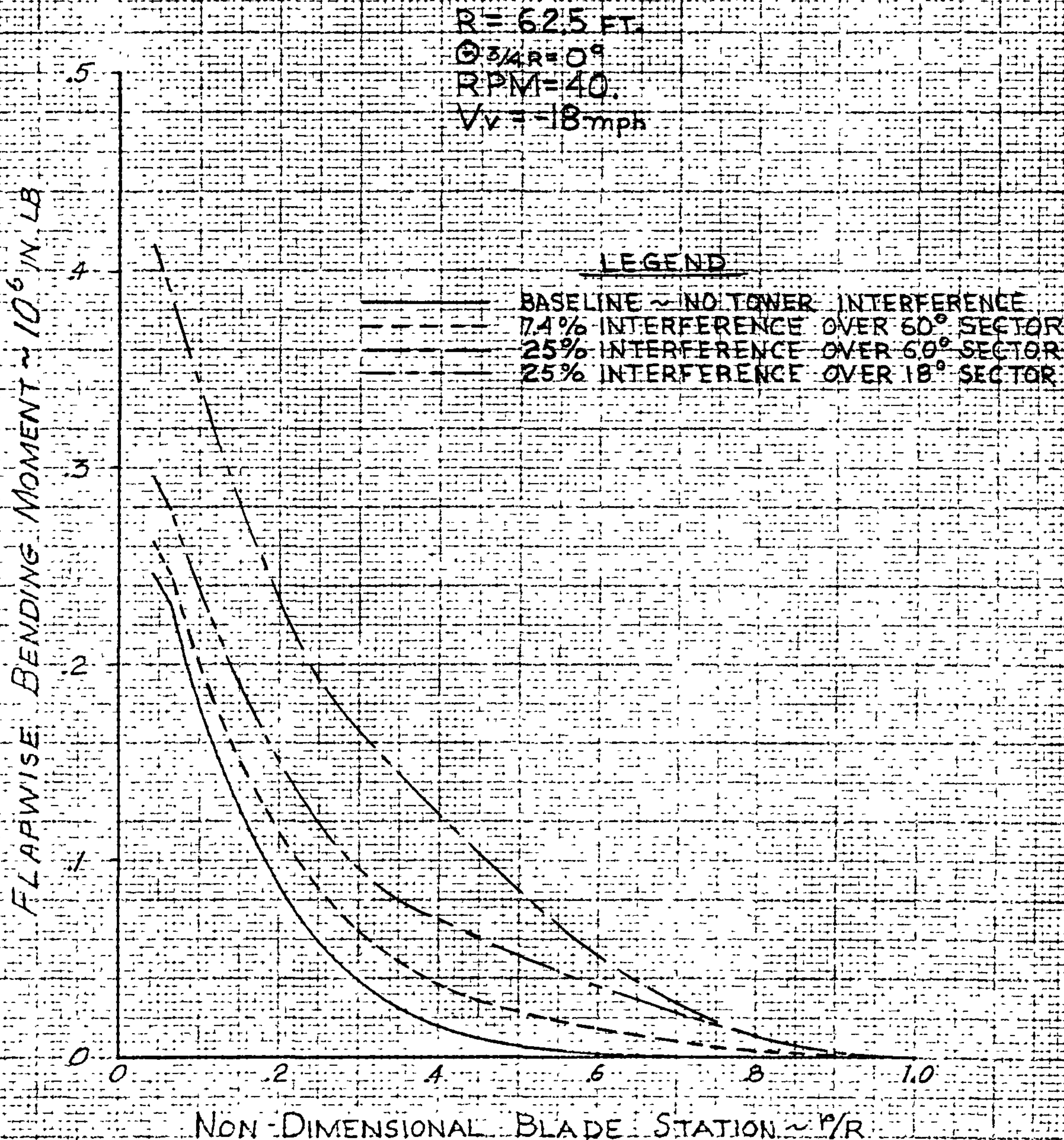


FIGURE 2.14

FORM 5278

WIND TURBINE CYCLIC BLADE LOADS COMPARISON
EFFECTS OF TOWER SHADOW INTERFERENCE
CHORDWISE BENDING MOMENT

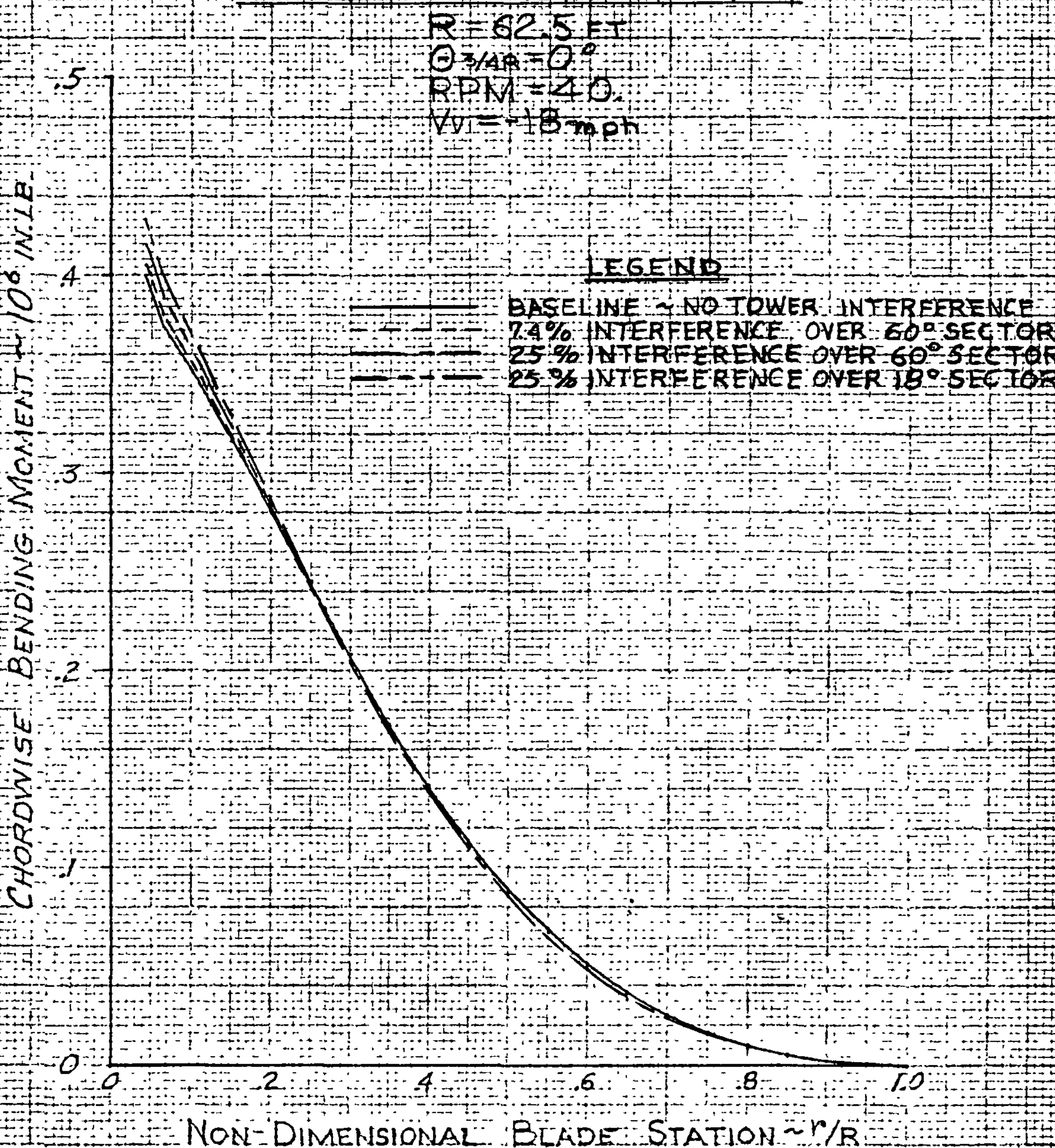
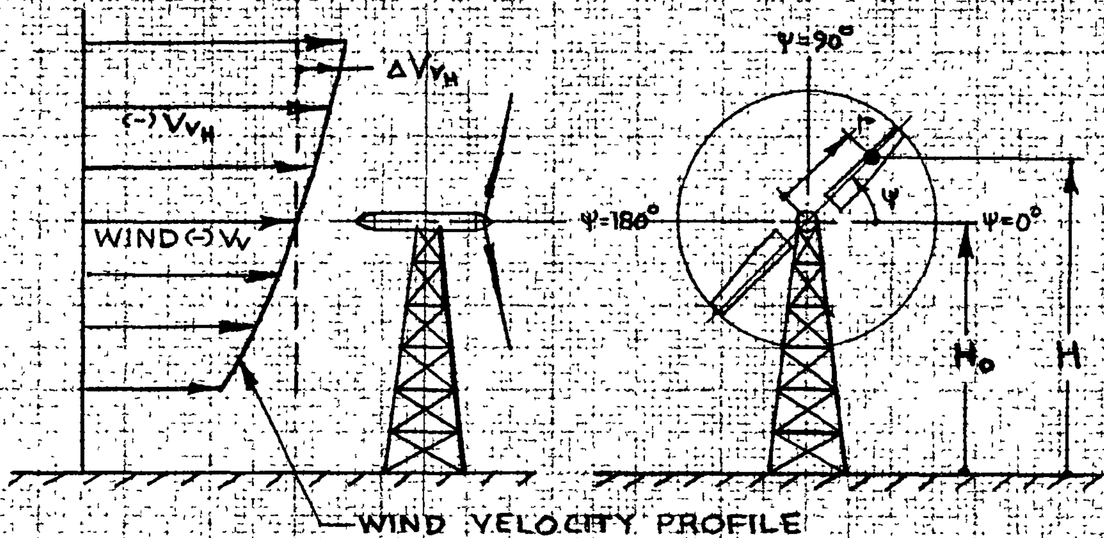


FIGURE 2.15

WIND SHEAR REPRESENTATION "WINTUR" PROGRAM



$$H = H_o + r \sin\psi$$

$$V_{V_H} = V_V\left(\frac{H}{H_o}\right)^{n}$$

$$\Delta V_{V_H} = [V_{V_H} - V_V] * K_W = V_V\left[\left(1 + \frac{r}{H_o}\sin\psi\right)^{n} - 1\right] * K_W$$

WHERE : ΔV_{V_H} = INCREMENTAL CHANGE IN WIND VELOCITY AT ALTITUDE, H ~ FEET PER SECOND.

V_H = NOMINAL WIND VELOCITY ~ FEET PER SECOND

H_o = ELEVATION OF ROTOR SHAFT AXIS ~ FEET

H = ALTITUDE OF BLADE ELEMENT ~ FEET

r = LOCAL BLADE RADIUS ~ FEET

ψ = BLADE AZIMUTH POSITION ~ DEGREES

n = EXPONENT DESCRIBING EARTH'S SURFACE ROUGHNESS

K_W = FACTOR: NORMALLY EQUAL TO 1.0 WHEN n IS LESS THEN 1.0. IF n IS EQUAL TO 1.0 THEN K_W DESCRIBES A LINEAR VARIATION OF WIND SHEAR GRADIENT

FIGURE 2.16

WIND TURBINE CYCLIC BLADE LOADS COMPARISON
EFFECTS OF TOWER SHADOW INTERFERENCE AND WIND SHEAR
BEAMWISE BENDING MOMENT

$R = 62.5$ FT
$\Theta_{3/4R} = 0°$
RPM = 40
$V_V = 18$ mph

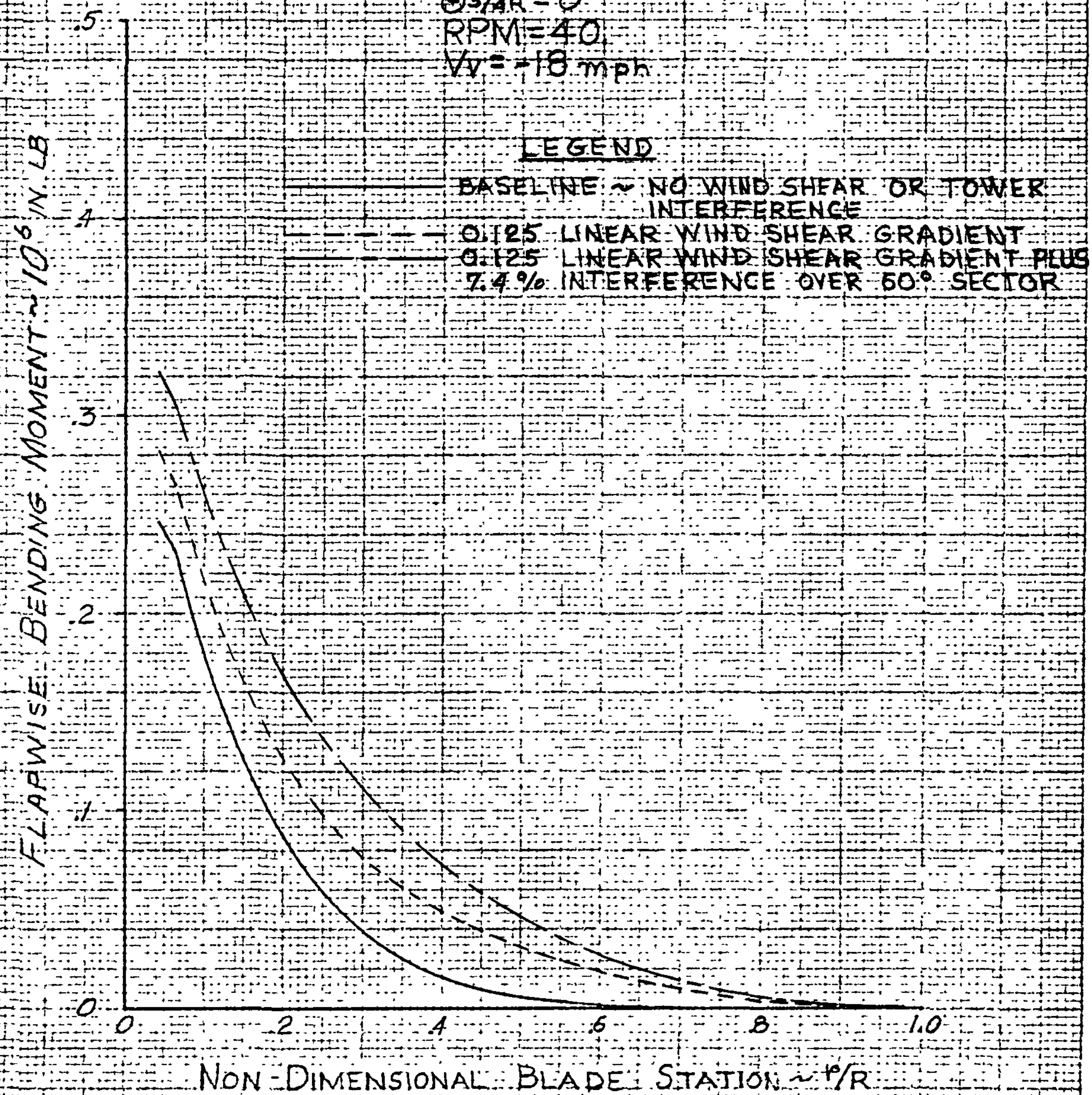


FIGURE 2.17

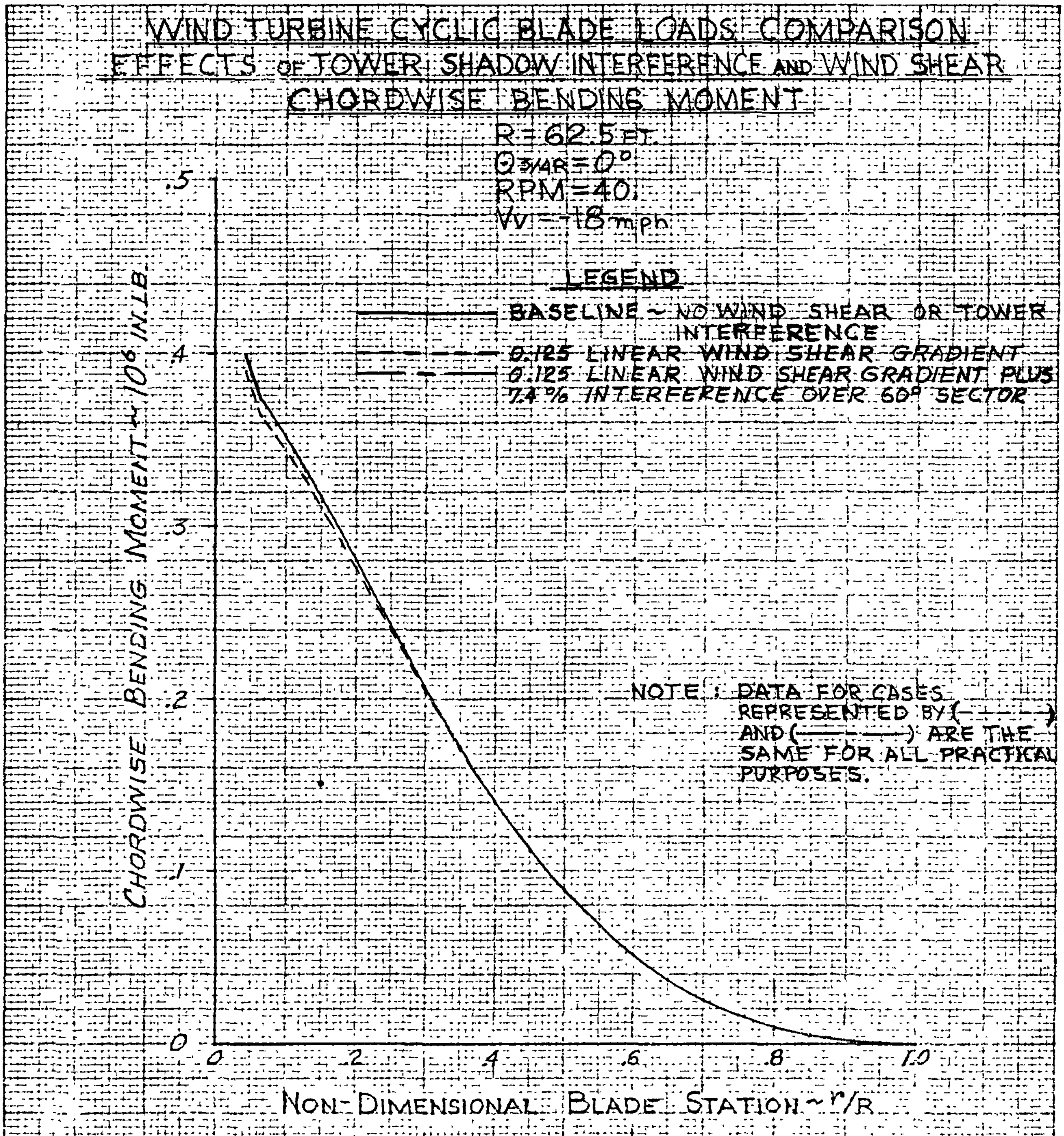

WIND TURBINE CYCLIC BLADE LOADS COMPARISON
EFFECTS OF TOWER SHADOW INTERFERENCE AND WIND SHEAR
CHORDWISE BENDING MOMENT
R = 62.5 FT
Θ3/4R = 0°
RPM = 40
VV = 18 mph
LEGEND
BASELINE ~ NO WIND SHEAR OR TOWER INTERFERENCE
0.125 LINEAR WIND SHEAR GRADIENT
0.125 LINEAR WIND SHEAR GRADIENT PLUS 7.4% INTERFERENCE OVER 60° SECTOR
NOTE: DATA FOR CASES REPRESENTED BY (— — —) AND (—— - ——) ARE THE SAME FOR ALL PRACTICAL PURPOSES.
CHORDWISE BENDING MOMENT ~ 10⁶ IN.LB.
.5
.4
.3
.2
.1
0
0
.2
.4
.6
.8
1.0
NON-DIMENSIONAL BLADE STATION ~ r/R

FIGURE 2.18

WIND TURBINE CYCLIC BEAMWISE BENDING MOMENT AZIMUTHAL COMPARISONS

STATION r/R=0.042
r/R=0.50

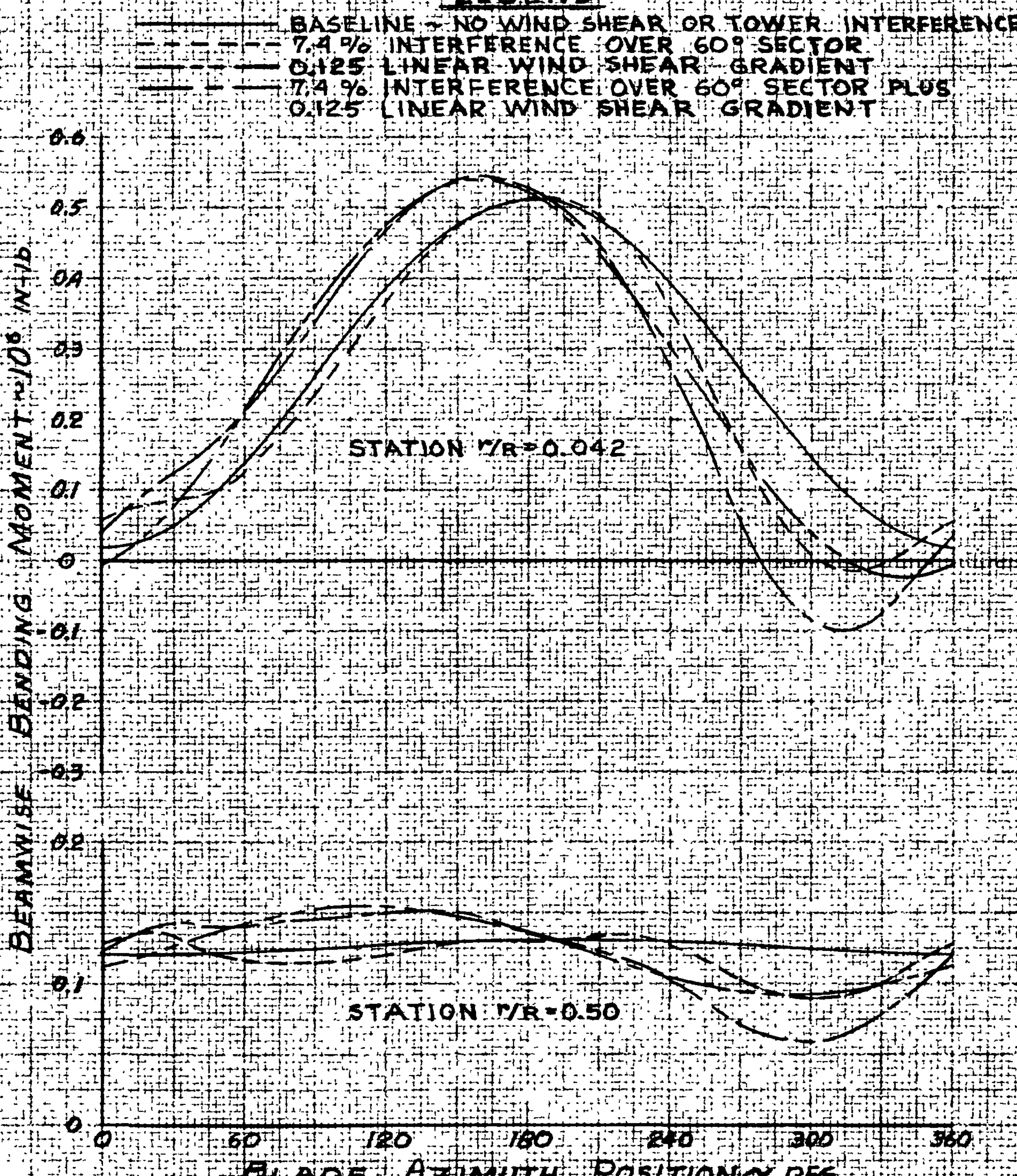


FIGURE 2.19

PREPARED BY: GAIDELIS	DATE:	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 2.34
CHECKED:		TITLE: TABLE 2.4 SHEET 1 OF 2 WINDMILL TOWER LOADS	MODEL:
APPROVED:			REPORT NO. LR 27153

CONDITION DATA

ROTOR SPEED = 40 RPM

CASE No.	NASA DESIGN CASE NO.	WIND VELOCITY FT/SEC. V_V	V_H	YAW RATE $\dot{\gamma}$ RAD/SEC	BLADE ANGLE $\Theta_{3/4R}$ DEG.	TOWER INTERFERENCE $\bar{\Psi}$	K_V	WIND SHEAR η	K_W	AXIAL THRUST T LB	SHAFT POWER Q HP	LEGEND REF. FIGURE THIS SECTION
501	1	-26.4	0	0	0	0	0	0	0	5437	-178.	(BASE LINE)
513	2	-88.0	0	0	0	0	0	0	0	13994	-242.	
509	3	-26.4	0	0	-90.	0	0	0	0	-292	4614.	
514	4	0	0	0	0	0	0	0	0	-385	37.	
511		-26.4	0	0	6.	0	0	0	0	8691	-205.	
512		-26.4	0	0	-6.	0	0	0	0	1458	-36.	
515		-26.1	4.59	.0349	0	0	0	0	0	5324	-173.	
516		-26.1	4.59	-.0349	0	0	0	0	0	5325	-174.	
5013		-26.4	0	0	0	60.	.074	0	0	5285.	-170.	- - - - -
5013A		-26.4	0	0	0	60.	.25	0	0	5018.	-155	——— - ———
5012		-26.4	0	0	0	18.	.25	0	0	5284.	-170.	- - ———
5014		-26.4	0	0	0	0	0	1.0	.125	5397.	-178.	- - - - -
5015		-26.4	0	0	0	60.	.074	1.0	.125	5286.	-171.	——— - ———

WINDMILL TOWER SHAFT MOMENTS

CASE No.	YAW MOMENT, M_H ~ IN-lb S_0	S_{2P}	Φ_{2P}	S_{4P}	Φ_{4P}	S_{6P}	Φ_{6P}	PITCH MOMENT, L_H ~ IN-lb S_0	S_{2P}	Φ_{2P}	S_{4P}	Φ_{4P}	S_{6P}	Φ_{6P}
501	-544	2893	51°	—		—		-118400	2889	96°	—		—	
513	297	2877	32°	—		—		-127645	2895	77°	—		—	
509	2364	15542	41°	—		—		-140500	15531	86°	—		—	
514	-8523	17370	121°	—		—		-129200	17400	166°	—		—	
511	-1341	2222	64°	—		—		-124200	2218	109°	—		—	
512	698	3802	41°	—		—		-112400	3801	86°	—		—	
515	-63152	142800	58°	—		—		9973	142800	103°	—		—	
516	148500	207600	158°	—		—		-273800	207600	23°	—		—	
5013	5042	49420	126°	29500	48°	—		-164000	49400	19°	23050	71°	—	
5013A	19080	174400	126°	99000	48°	—		-274000	174600	19°	77290	71°	—	
5012	5798	81900	113°	62600	49°	15340	22°	-168700	81890	32°	83990	71°	29900	13°
5014	16060	113800	141°	3	37°	3	15°	-232600	113800	6°	1	183°	3	49°
5015	21850	161900	137°	29340	48	—		-278800	162900	10°	22910	71°	—	

$$\text{LOAD} = S_0 + S_{2P}\cos 2(\psi-\Phi_{2P}) + S_{4P}\cos 4(\psi-\Phi_{4P}) + S_{6P}\cos 6(\psi-\Phi_{6P})$$

FORM 362B-2

TITLE: TABLE 2.4 SHEET 2 OF 2
WINDMILL TOWER LOADS

WINDMILL SHAFT NORMAL FORCES

CASE	YAW FORCE, H ~ POUNDS							PITCH FORCE, Y ~ POUNDS						
NO.	S_0	S_{2P}	ϕ_{2P}	S_{4P}	ϕ_{4P}	S_{6P}	ϕ_{6P}	S_0	S_{2P}	ϕ_{2P}	S_{4P}	ϕ_{4P}	S_{6P}	ϕ_{6P}
501	4	278	45°	—		—		-5582	278	90°	—		—	
513	3	283	43°	—		—		-5588	283	88°	—		—	
509	-11	464	44°	—		—		-5564	464	1°	—		—	
514	-1	270	45°	—		—		-5584	270	90°	—		—	
511	1	270	45°	—		—		-5582	270	90°	—		—	
512	4	289	45°	—		—		-5582	289	90°	—		—	
515	-3	268	51°	—		—		-5556	267	96°	—		—	
516	95	360	40°	—		—		-5668	360	85°	—		—	
5013	-24	270	38°	48	108°	—		-5603	254	86°	52	152°	—	
5013A	-82	290	25°	152	54°	—		-5651	218	75°	163	76°	—	
5012	-22	283	37°	140	54°	6	24°	-5605	237	87°	127	77°	32	50°
5014	-44	248	33°	0		0		-5634	248	78°	0		0	
5015	-69	262	27°	45	54°	—		-5654	240	74°	49	76	—	

$$\text{LOAD} = S_0 + S_{2P}\cos 2(\psi - \phi_{2P}) + S_{4P}\cos 4(\psi - \phi_{4P}) + S_{6P}\cos 6(\psi - \phi_{6P})$$

SECTION 3.

STRESS ANALYSIS.

INTRODUCTION

THIS SECTION OF THE REPORT SUBSTANTIATES THE STRUCTURAL INTEGRITY AND THE FATIGUE LIFE DESIGN GOAL OF THE 3 METAL WINDMILL BLADES FOR NASA-LEWIS IN COMPLIANCE WITH SPECIFICATION N° 3-572243 FOR CONTRACT NAS 3-19235.

PREPARED BY a Smith	DATE 6/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.2
CHECKED		TITLE 100 KW WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

STRUCTURAL DESCRIPTION

THE CONSTRUCTION OF THE BLADE COMPRISES AN ALL ALUMINUM HEAVY WALL 'D' SECTION (.250t.) REINFORCED WITH A SPAR AND LONGITUDINAL STRINGERS. THE SKIN AFT OF THE SPAR IS LIGHT .040" THICK COVER WITH A TRIANGULAR CLOSURE MEMBER. THE TRANSITION TO THE ROOT ATTACHMENT IS MADE BY TWO HEAVY ALUMINUM RIBS WHICH TRANSFER THE BLADE LOADS TO A TUBULAR STEEL HUB FLANGED AT THE INBOARD END FOR ATTACHMENT TO THE N.A.S.A. WINDMILL HUB WITH A BOLT PATTERN AND SIZE ESTABLISHED BY N.A.S.A.

FORM 362B-2

PREPARED BY	DATE	LOCKHEED - CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE
A.W.Cherritt	6-13-75		3.3
CHECKED		TITLE: 100 KW WINDMILL BLADE	MODEL CL 1708
APPROVED			REPORT NO LR 27153

Blade Internal Loads and Stresses

The internal loads and stresses are calculated for the four design cases listed on Table I of the contract. External loads for these cases are shown in Section 2 and comprise mean and cyclic loads for case 3, mean loads for cases 1, 2, and 4 and one cyclic loading common to these latter three cases. The internal loads and stresses are presented in Appendix A and summarized on pages 3 20 to 3.31.

The primary internal loads producing significant stresses are the axial loads from combined beamwise and chordwise bending moments. The mechanized program used for deriving the internal loads is described on page 3 4. The method provides an accurate representation of the axial stresses along the blade for the section properties used.

The effect of varying the section properties to be consistent with the developed stress for each condition is discussed on page 3.14. The shear flows, however, for both direct shear and torsional shear are conservative. This is due to the fact that no account is taken of blade taper and the torsion box areas calculated within the program use straight lines between the neutral axes of the areas lumped at the grid points and do not follow the skin contour. Since the shear stresses generally are relatively low, correction of the shear flows is not considered warranted, except for the spar web for case 3, where the correction is made to show the web to be shear resistant (reference page 3.16).

Axial stresses from centrifugal force are presented on page 3.19.

The design loads used are from section 2 of this report. The centrifugal force is from Fig. 2.12. Blade Bending moments and shears are from Figs. 2.6 to 2.11. The shears in these figures are given relative to the shaft axis and have been rotated to each blade section reference axis for determining internal loads. Blade torsion is obtained from runs of the "winturs" program described on page 2.1 for the design conditions analyzed.

MECHANIZED ANALYSIS PROGRAM

The internal loads and section properties are calculated with the aid of remote terminal computations using the Conversational Programming System (C.P.S.). Inputs to the program at any station analyzed are as follows:

A ins^2	cross-sectional areas assigned to grid points chosen for the structural model.
X ins Z ins	coordinates about the established reference axes.
T ins	thickness of skin between grid points.
TMS ins	spar web thickness.
XMS ins ZMS ins	spar location relative to the reference axis.
HMS ins	spar height.
E lb/in^2	Modulus of Elasticity for material used.
G lb/in^2	Shear Modulus of material used.
XLA ins ZLA ins	coordinates about the reference axis of the load application point.
Sx lb. Sz lb.	applied shear loads at the load application point along the x and z reference axes.
Mx lb/ins Mz lb/ins	applied bending moments, about the reference axis at the load application point.
My lb/ins	tonsional moment about the load application point.

The program uses the above material, geometric and applied load data to compute and print out the following data:

$\bar{x}$ ins $\bar{z}$ ins	coordinates of the neutral axis position of the cross-section about the reference axis.
EIxx EIzz EIxz	Product of area moments of inertia times the modulus of elasticity about the neutral axis location.
LOAD lb STRESS psi	axial load and stress at each grid point.

MECHANIZED ANALYSIS PROGRAM (Cont'd)

q lb/in — shear flows in the spar web in the skins between grid points.

2A cell 1
2A cell 2 — computed torsion base areas of front and rear blade cells.

Q lb/in — shear due to torsion alone in each cell.

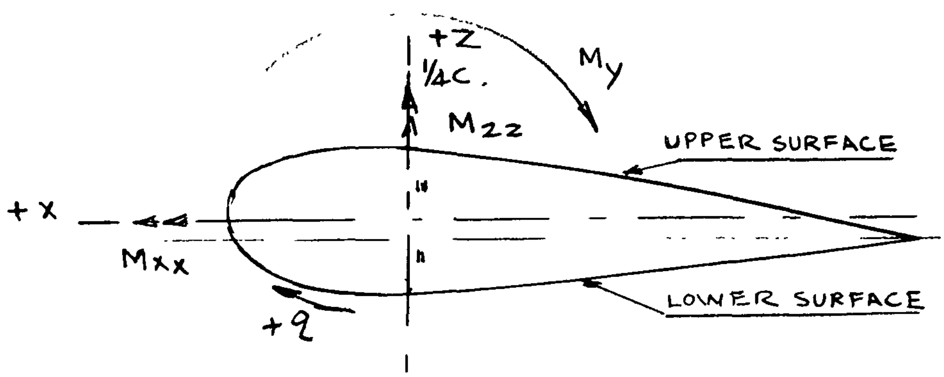
My in/lbs — torsion about shear center.
Lateral location of shear center in inches ahead of spar.

The program output data for the blade stations and load condition analyzed is presented in Appendix A.

BLADE SECTION PROPERTIES.

THE BLADE SECTION PROPERTIES ARE CALCULATED WITH THE AID OF THE "CPS" COMPUTER PROGRAM DESCRIBED ON PAGE 3.4 . THE PROPERTIES ARE CALCULATED AT TWELVE STATIONS ALONG THE BLADE. THE REFERENCE AXES USED AT EACH STATION ARE AS FOLLOWS:-

THE 'X' AXIS IS A LINE PARALLEL TO THE CHORD LINE WHICH BISECTS THE AIRFOIL ORDINATE AT THE 1/4 CHORD. THE 'Z' AXIS IS NORMAL TO THE X AXIS AT THE 1/4 CHORD. THESE AXES TOGETHER WITH THE SIGN CONVENTION USED IS SHOWN IN THE SKETCH BELOW.



WITH RESPECT TO THE AIRFOIL SECTION

X POSITIVE FORWARD.

Z POSITIVE UP

M_{xx} POSITIVE UPPER SURFACE IN COMPRESSION

M_{yy} POSITIVE NOSE UP

M_{zz} POSITIVE T.E. IN COMPRESSION

q SHEAR FLOWS POSITIVE NOSE UP.

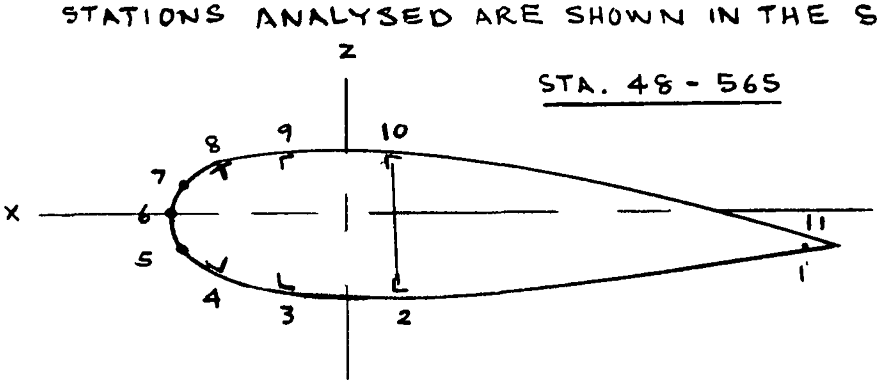
NOTE THE SIGN CONVENTION IS THE SAME AS FOR THE LOADS ANALYSIS, SECTION 2 FIG 2.1 EXCEPT THAT THE POSITIVE 'X' DIRECTION IS REVERSED.

BLADE SECTION PROPERTIES

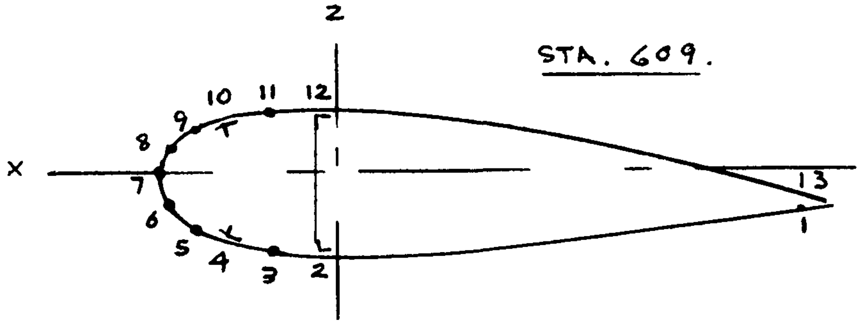
AT EACH BLADE SECTION ANALYSED THE AREAS ARE LUMPED AT CONVENIENT GRID POINTS STARTING WITH GRID POINT N° 1 AT THE LOWER TRAILING EDGE. ALL THE BLADE SKIN FORWARD OF THE SPAR IS FULLY EFFECTIVE. AT THE SPAR 1.0 INCH OF BOTH THE .040 TRAILING EDGE SKIN & THE .080 SPAR WEB IS ASSUMED EFFECTIVE. THE TRAILING EDGE SKINS FROM THE SPAR TO THE REGION OF THE TRAILING EDGE CLOSURE ARE ASSUMED INEFFECTIVE. AT THE TRAILING EDGE CLOSURES AN EFFECTIVE WIDTH OF SKIN CONSISTANT WITH THE T.E. COMPRESSIVE STRESS FROM CASE 2 IS ADDED TO THE CLOSURE AREAS. THE EFFECT OF THIS ASSUMPTION IS DISCUSSED ON PAGE 3.14.

THE LOCATION OF THE GRID POINTS FOR THE BLADE STATIONS ANALYSED ARE SHOWN IN THE SKETCHES BELOW

STA. 48 - 565



STA. 609.



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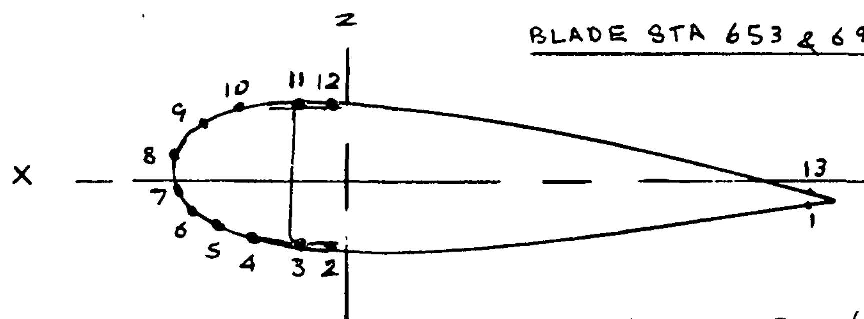
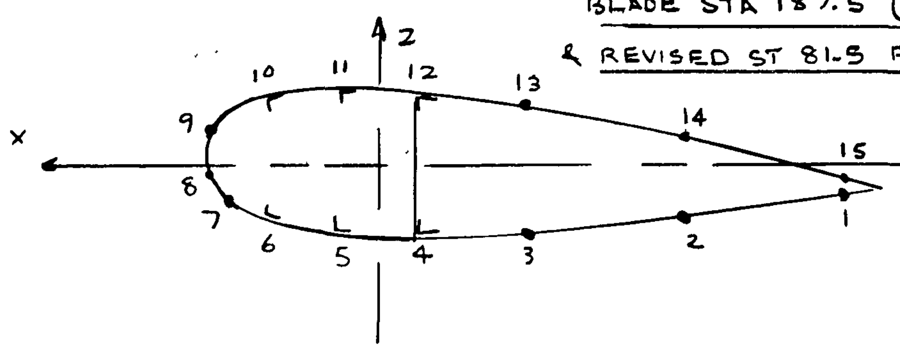
APPROVED			REPORT NO. 27153

BLADE SECTION PROPERTIES.

BLADE STA 653 & 697.



BLADE STA 187.5 (FATIGUE).
& REVISED ST 81.5 FOR CASE 3.



SECTION PROPERTY OUTPUT DATA IS PRESENTED IN APPENDIX A AND IS PLOTTED ON PAGES 3.11 & 3.12

BLADE SECTION PROPERTIES.

TORSIONAL STIFFNESS.

THE TORSIONAL STIFFNESS IS CALCULATED AT SECTIONS ALONG THE BLADE SPAN AND IS PLOTTED ON PAGE 3.13 .

THE SPAR WEB DIVIDES THE BLADE INTO A THICK SKINNED LEADING EDGE 'D' SHAPED BOX AND A THIN SKINNED TRIANGULAR TRAILING EDGE BOX. THE TORSIONAL STIFFNESS IS EVALUATED BY THE METHOD DESCRIBED IN BRUHN REF. 1 . A TYPICAL CALCULATION MADE AT STATION 301 IS PRESENTED BELOW.

STATION 301

AREA OF CELL (1) LEADING EDGE BOX $A_1 = 191 \text{ INS}^2$

AREA OF CELL (2) TRAILING EDGE BOX $A_2 = 195 \text{ INS}^2$

TOTAL ENCLOSED AREA $A = 386 \text{ INS}^2$

$a_{10} = \ell/t$ AROUND NOSE FROM UPPER SPAR TO LOWER SPAR

$$= 42/.25 \qquad = \underline{168}$$

$a_{20} = \ell/t$ AROUND TRAILING EDGE BOX.

$$= 3.0/.25 + 1.8/.08 + 48.4/.04 \qquad = \underline{1244}$$

$a_{12} = \ell/t$ SPAR WEB COMMON TO BOTH TORQUE BOXES

$$\approx 11.7/.08 \text{ (EFFECTIVE)} \qquad = \underline{146}$$

$$J = \left[\frac{a_{20}A_1^2 + a_{12}A^2 + a_{10}A_2^2}{a_{10} \times a_{12} + a_{12}a_{20} + a_{20}a_{10}}\right]4$$

BLADE SECTION PROPERTIES

TORSIONAL STIFFNESS

STATION 301.

$$J = \left[\frac{1244 \times 191^2 + 146 \times 386^2 + 168 \times 195^2}{168 \times 146 + 146 \times 1244 + 1244 \times 168} \right] 4$$

$$J = \left[\frac{73.52 \times 10^6}{.415 \times 10^6} \right] 4 \qquad = \underline{708.6 \text{ INS}^4}$$

TORSIONAL STIFFNESS = GJ $\quad G = 4.0 \times 10^6$

$$GJ = 4.0 \times 708.6 \times 10^6 \qquad = \underline{2.83 \times 10^9}$$

SHEAR FLOW IN FORWARD BOX q_1

$$q_1 = \frac{1}{2}\left[\frac{a_{20} A_1 + a_{12} A}{73.52 \times 10^6}\right] T = \frac{1}{2}\left[\frac{1244 \times 191 + 146 \times 386}{73.52 \times 10^6}\right]$$

$$q_1 = \underline{.00200\ T.}$$

$$q_2 = \frac{1}{2}\left[a_{10} A_2 + a_{12} A\right] T = \frac{1}{2}\left[\frac{168 \times 195 + 146 \times 386}{73.52 \times 10^6}\right]$$

$$q_2 = \underline{.000606\ T}$$

CHECK THESE SHEAR FLOWS AGAINST THOSE CALCULATED FROM THE MECHANIZED ANALYSIS PAGE 3.A.20

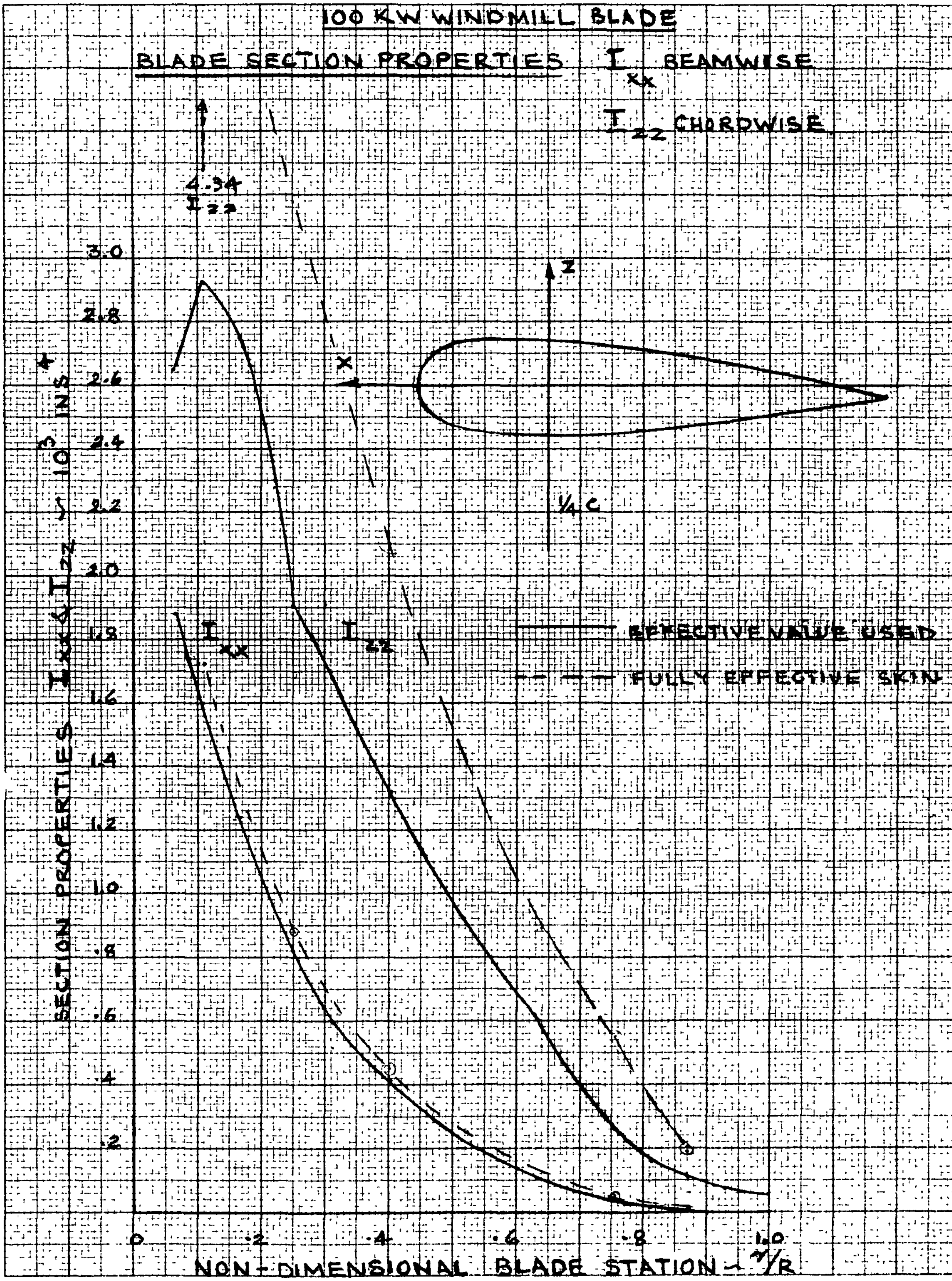
$$q_1 = 21.93/9358.65 \qquad = \underline{.00234\ T}$$

$$q_2 = 5.66/9358.65 \qquad = \underline{.000605\ T}$$

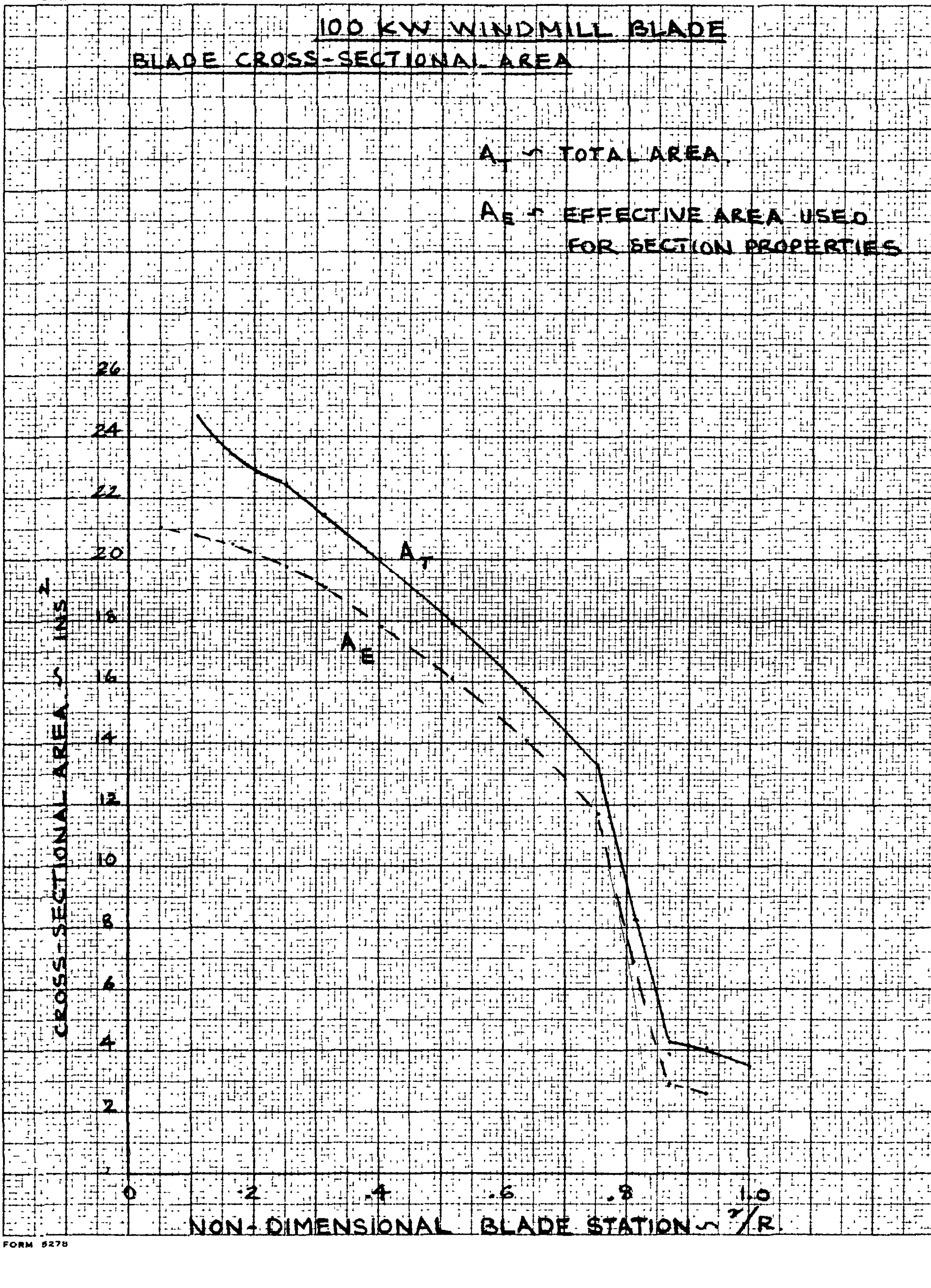
THE MECHANIZED PROGRAM CHECKS REASONABLY WELL FOR THE TRAILING EDGE BOX BUT IS APPROXIMATELY 17% CONSERVATIVE FOR THE LEADING EDGE BOX.

PREPARED BY A. CHERRITT
DATE 3/75
CHECKED BY

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION



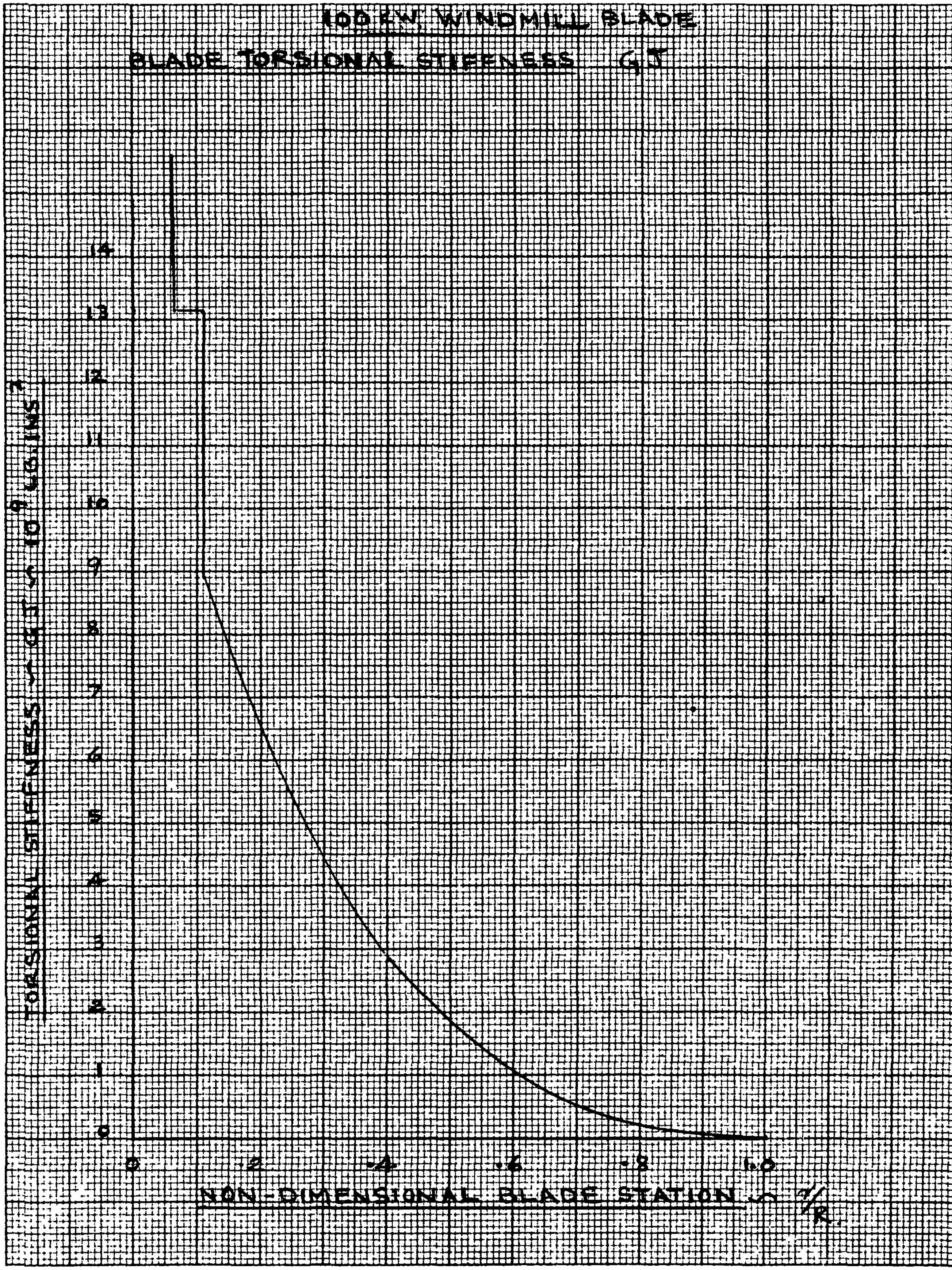
FORM 8278


100 KW WINDMILL BLADE
BLADE CROSS-SECTIONAL AREA
A_T ~ TOTAL AREA
A_E ~ EFFECTIVE AREA USED FOR SECTION PROPERTIES
A_T
A_E
CROSS-SECTIONAL AREA ~ INS^2
26
24
22
20
18
16
14
12
10
8
6
4
2
0
.2
.4
.6
.8
1.0
NON-DIMENSIONAL BLADE STATION ~ r/R

PREPARED BY A CHERRITT
DATE 6/75.
CHECKED BY

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

PAGE 3.13
MODEL CL1708
REPORT NO. 27153



FORM 5278

EFFECT OF INCLUDING TRAILING EDGE SKIN ON BLADE PROPERTIES AND STRESSES

THE SECTION PROPERTIES USED IN THE MECHANIZED PROGRAM FOR THE CALCULATION OF INTERNAL LOADS & STRESSES ASSUME THAT THE .040 INCH THICK TRAILING EDGE SKIN IS INEFFECTIVE FOR TAKING LOAD EXCEPT AT THE EXTREME TRAILING EDGE. HERE THE AREA OF SKIN CONSISTANT WITH THE ANTICIPATED COMPRESSIVE STRESS FOR CASE 2 IS INCLUDED WITH THE AREA OF THE TRAILING EDGE CLOSURES. THE EFFECT ON THE BLADE SECTION PROPERTIES OF USING FULLY EFFECTIVE TRAILING EDGE SKIN IS SHOWN ON PAGE 3.11. THE EFFECT ON BEAMWISE I_{xx} IS SMALL BUT THE EFFECT ON CHORDWISE I_{zz} IS CONSIDERABLE.

FOR DESIGN CASE I, WHERE THE DEVELOPED STRESSES ARE LOW AND FOR CASE 3 WHERE MOST OF THE TRAILING EDGE SKIN IS IN TENSION, THE STRESSES ARE LOWER THAN CALCULATED BY THE MECHANIZED PROGRAM. THIS EFFECT IS CONSERVATIVELY NEGLECTED EXEPT FOR THE FATIGUE ANALYSIS, CASE I, AT THE HIGHEST STRESSED STATION AND ALSO FOR THE INBOARD BLADE TRAILING EDGE STRESS FOR CASE 3.

FATIGUE LOADS AND STRESSES

THE HIGHEST STRESSED AREA OF THE BLADE FOR THE FATIGUE CONDITION IS IN THE REGION OF BLADE STATION 187.5. AT THIS STATION THE STRESSES FOR CASE I ARE CALCULATED WITH FULLY EFECTIVE SKIN AND ARE PRESENTED ON PAGES 3A.92-3A.94. A COMPARISON OF THE STRESS AT GRID POINT 11 SHOWS THAT THE CYCLIC TRAILING EDGE STRESS CHANGED FROM -5327 PSI TO -3035 PSI PAGES 3A.70 & 3A.94

EFFECT OF INCLUDING TRAILING EDGE SKIN ON BLADE PROPERTIES AND STRESSES.

CASE 3 TRAILING EDGE STRESS.

THE TRAILING EDGE TENSILE STRESSES ARE THOSE MOST AFFECTED BY THE CONSERVATISM IN THE SECTION PROPERTIES USED. THESE STRESSES ARE RECALCULATED FOR THE INBOARD BLADE STATIONS USING EFFECTIVE TRAILING EDGE SKIN AREAS CONSISTANT WITH THE STRESSES DEVELOPED. THE RESULTS ARE SHOWN BELOW AND ARE ADDED TO THE SUMMARY TABLE PAGE 3.29 FOR COMPARISON. A C.P.S. PROGRAM RUN IS ALSO MADE FOR RIB REACTION AT 81.5 WITH THE REVISED PROPERTIES FOR CASE 3 MEAN + CYCLIC (REF PAGE 3A.95)

STATION INS	I_{xx} INS^4	I_{zz} INS^4	I_{xz} INS^4	X_{NA}	Z_{NA}	CASE 3* STRESS PSI
81.5	1660	4230	43	-1.17	.15	23500
187.5	857	3049	47	-.83	.02	18600
301	431	1731	-18	-.34	.11	12100
389	238	1365	15	-.80	-.06	7250

* GRID PT. 11, INCLUDES C.F. & MEAN + CYCLIC LOADS.

EFFECT OF BLADE TAPER ON BEAMWISE SHEAR FORCES.

THE MECHANIZED METHOD FOR CALCULATING THE INTERNAL FORCES ALONG THE BLADE SPAN DOES NOT INCLUDE THE EFFECT OF BLADE TAPER. THE BLADE TAPERS IN BOTH THICKNESS AND CHORD. THE CHORDWISE EFFECT IS SMALL, HOWEVER, AND WILL BE IGNORED. THE BEAMWISE EFFECT OF TAPER CAN BE LARGE AND WILL BE EVALUATED HERE. CASE 3 IS THE ONLY CONDITION WITH SIGNIFICANT SHEAR FLOWS, PATICULARLY IN THE SPAR WEB. THE CORRECTION FACTOR FOR SPAR WEB SHEAR FLOWS IS CALCULATED OVERLEAF FOR CASE 3 AND THE RESULTS ARE FEATURED IN THE SUMMARY TABLE ON PAGE 3.28

PREPARED BY a Sherritt (signature)	DATE 6/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.17
CHECKED		TITLE 100 KW. WINDMILL BLADE	MODEL CL 1708
APPROVED			REPORT NO. 27153

EFFECT OF BLADE TAPER ON BEAMWISE SHEAR FORCES.

1 BLADE STATION x INS.	2 x/R	3 CHORD INS.	4 t/c	5 t_{MAX} INS.	6 Δt INS.	7 SLOPE TANGENT $\Delta t / 2\Delta x$	8 CASE 3 MEAN SURFACE LOAD LB.	9 SHEAR IN SURFACES LB.
81.5	.109	54	.415	22.41			144270	-8714
					2.59	.0298		
125	.167	54	.367	19.82			148660	-8741
					3.62	.0290		
187.5	.250	54	.300	16.20			154830	-5605
					1.69	.0178		
235	.313	50.96	.285	14.51			154170	-5273
					2.18	.0165		
301	.401	46.74	.264	12.33			138410	-4401
					2.65	.0151		
389	.518	41.10	.235	9.68			118360	-3338
					2.32	.0132		
477	.636	35.47	.207	7.36			92390	-2273
					2.01	.0114		
565	.753	29.84	.179	5.35			60540	-1302
					.89	.0101		
609	.812	27.02	.165	4.46			40970	-778
					.80	.0091		
653	.871	24.21	.151	3.66			23420	-403
					.73	.0083		
697	.930	21.39	.137	2.93			12580	-199
					.77	.0073		
750	1.000	18.00	.120	2.16			0	0

9 = SURFACE LOAD x 2 x TAN. SLOPE.

FORM 3628-2

EFFECT OF BLADE TAPER ON BEAMWISE SHEAR FORCES.

1	10	11	12	13	14	15	16	17
				CASE 3 SPARWEB MEAN + CYCLIC.				
BLADE STATION	S_z MEAN CASE3 LB.	ΔS 10 − 9	SHEAR FACTOR $\Delta S/S_z$ K_s	q_{TOTAL} LB/IN	$q_{TORSION}$ LB/IN.	q_{sz} 13 − 14 LB/IN	$K_s q_{sz}$ LB/IN	q RES. 14 + 16 LB/IN
81.5	-7010	+1704	-.243	-309	-152	-157	38	-114
125	-7340	+1401	-.191	-307	-161	-146	28	-133
187.5	-7500	-1895	.253	-375	-187	-188	-47	-229
235	-7435	-2162	.291	-413	-201	-212	-62	-273
301	-7100	-2699	.380	-482	-224	-258	-98	-322
389	-6250	-2912	.466	-532	-268	-364	-170	-438
477	-5010	-2737	.546	-632	-288	-344	-188	-476
565	-3495	-2193	.627	-696	-309	-387	-243	-552
609	-2650	-1872	.706	-711	-310	-401	-283	-593
653	-1810	-1407	.777	-692	-279	-413	-321	-600
697	-1160	-961	.828	-600	-253	-347	-287	-540
750	0	0	1.000	0	0	0	0	0

NOTE:- THE K_s APPLIES ONLY TO COND 3 AND IS A FUNCTION OF BEAMWISE BENDING DISTRIBUTION & ALSO CHORDWISE LOADING ON A TWISTED BLADE.

PREPARED BY A. CHERRITT	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.19
CHECKED		TITLE 100 KW. WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

BLADE STRESS FROM CENTRIFUGAL FORCE

BLADE STATION INS.	r/R	C.F. LB	BLADE AREA. INS²	f_{CF} LB/IN²
48	.064	0	—	0
81.5 IN'BD	·109	- 1100	24.7	- 40
81.5 OUT'BD	·109	23300	24.7	940
125	·167	22400	23·4	960
187.5	·250	21100	22·5	940
235	·313	19900	21 5	925
301	·401	17700	20·0	885
389	·518	13800	17·9	770
477	·636	9500	15·8	600
565	·753	5300	13·3	400
609	·812	3400	8·2	415
653	·871	2100	4·3	490
697	·930	1000	4·1	240
750	1·000	0	3.5	0

FORM 3628-2

SUMMARY OF INTERNAL LOADS & STRESSES.

THE FOLLOWING PAGES SUMMARIZE THE INTERNAL LOADS AND STRESSES FOR THE FOUR DESIGN CASES ANALYSED. THE DATA IS OBTAINED FROM THE MECHANISED OUTPUT SHEETS PRESENTED IN APPENDIX A. STRESS FROM CENTRIFUGAL FORCE FROM PAGE 3.19 IS INCLUDED WHERE APPLICABLE.

SUMMARY OF MAXIMUM UPPER SURFACE STRESS

STRESS ~ PSI

BLADE STATION INS.	DESIGN CASE.			
	1	2	3	4
48	0	0	0	0
81.5	- 810 ± 1720	-4640 ± 1000	19910	5150 ± 1000
125	- 900 ± 1420	- 5300 ± 720	21270	5040 ± 720
187.5	- 1230 ± 1540	- 6470 ± 280	23210	4720 ± 280
235	- 1320 ± 1000	- 6850 ± 160	23760	4350 ± 160
301	- 1580 ± 740	- 6600 ± 40	22050	3410 ± 40
389	- 2510 ∓ 15	- 6600 ∓ 15	20450	1870 ± 480
477	- 3000 ∓ 35	- 6550 ∓ 35	17990	800 ± 450
565	- 2830 ∓ 60	- 5150 ∓ 60	13420	250 ± 290
609	- 3830 ± 20	- 6580 ± 20	15500	- 130 ± 20
653	- 5070 ± 30	- 9490 ± 30	19140	- 430 ± 30
697	- 3160 ± 10	- 6510 ± 10	11690	- 330 ± 10

PREPARED BY A. Lehrer(?)	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.22
CHECKED		TITLE 100 K.W. WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

SUMMARY OF MAXIMUM LOWER SURFACE STRESS.

STRESS ~ PSI

BLADE STATION INS	DESIGN CASE.			
	1	2	3	4
48	0	0	0	0
81.5	3000 ∓ 1300	8280 ± 730	-17750	-2890 ∓ 1300
125	3130 ∓ 1770	8310 ± 775	-19010	-2700 ∓ 1040
187.5	3400 ∓ 890	9200 ± 980	- 19420	-2410 ∓ 890
235	3730 ∓ 690	9390 ± 940	- 19470	-2280 ∓ 690
301	3820 ∓ 400	8630 ± 790	- 18900	-1520 ± 320
389	4040 ∓ 610	8060 ± 310	- 17260	- 650 ∓ 210
477	4180 ∓ 50	7240 ∓ 50	-16090	220 ∓ 430
565	3730 ∓ 20	5530 ∓ 20	- 12330	370 ± 340
609	4390 ± 90	8130 ± 90	- 14450	910 ± 90
653	5700 ± 110	10730 ± 110	-18200	1320 ± 110
697	3710 ± 70	7300 ± 70	-11760	880 ± 70

FORM 362B-2

PREPARED BY a [signature] DATE 5/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.23
CHECKED	TITLE 100 KW WINDMILL BLADE	MODEL CL1708
APPROVED		REPORT NO. 27153

SUMMARY OF SURFACE SHEAR FLOWS & STRESSES

CASE 1 & 2

BLADE STATION INS.	CASE 1		CASE 2	
	q LB/IN	f_s PSI	q LB/IN	f_s PSI
48	227 ± 195	910 ± 780	797 ± 77	3190 ± 310
81.5 IN'BD	277 ± 198	1110 ± 790	769 ± 93	3075 ± 370
81.5 OUT'BD	68 ∓ 29	270 ∓ 120	− 171 ∓ 6	− 685 ∓ 25
125	91 ∓ 16	365 ∓ 65	− 175 ∓ 7	− 700 ∓ 30
187.5	114 ± 13	455 ± 50	− 191 ∓ 9	− 765 ∓ 35
235	129 ∓ 9	520 ∓ 35	− 197 ∓ 10	− 789 ∓ 40
301	137 ± 7	550 ± 30	− 207 ∓ 10	− 830 ∓ 40
389	163 ∓ 2	650 ∓ 10	214 ∓ 2	855 ∓ 10
477	174 ± 2	700 ± 10	205 ∓ 7	820 ∓ 30
565	143 ± 1	570 ± 5	213 ± 1	850 ± 5
609	122 ± 1	980* ± 10	102 ± 1	815* ± 10
653	60 ± 1	480* ± 10	251 ± 4	1005 ± 15
697.	43 ± 0	345* ± 0	295 ± 5	1180 ± 20

* $t = .125''$ OTHERWISE $.25''$

FORM 362B-2

SUMMARY OF SURFACE SHEAR FLOWS & STRESSES

CASE 3&4

BLADE STATION INS.	CASE 3.		CASE 4.	
	q LB/IN	f_s PSI	q LB/IN	f_s PSI
48	2159	8640	364 ± 195	1455 ± 780
81.5 IN'BD.	2648	10590	488 ± 198	1950 ± 790
81.5 OUT'BD	343	1370	7 ± 34	30 ± 135
125	348	1390	11 ± 23	45 ± 90
187.5	385	1540	10 ± 23	40 90
235	403	1610	14 ± 18	55 70
301	430	1720	15 ± 18	60 70
389	465	1860	39 ± 6	155 25
477	475	1900	57 ± 2	230 10
565	477	1910	76 ± 1	305 5
609	500	2000	47 ± 1	375 * 10
653	255	2040 *	24 ± 0	190 * 0
697	300	2400 *	21 ± 0	170 * 0

* t = .125" OTHERWISE .250"

SUMMARY OF SPAR CAP STRESS

CASE 1 & 2. STRESS f psi

BLADE STATION INS	CASE 1 LWR. CAP	CASE 1 UPP. CAP	CASE 2 LWR. CAP	CASE 2 UPP CAP
48	0	0	0	0
81.5	3050 ∓ 2110	-1000 ± 210	2150 ∓ 2110	-7320 ± 210
125	3160 ∓ 1770	-1120 ∓ 40	2830 ∓ 1770	-7890 ∓ 40
187.5	3470 ∓ 1760	-1270 ∓ 660	2580 ∓ 1760	-9590 ∓ 660
235	3720 ∓ 1410	-1580 ∓ 690	3620 ∓ 1410	-9810 ∓ 690
301	3850 ∓ 1000	-1740 ∓ 680	3510 ∓ 1000	-9050 ∓ 680
389	4080 ∓ 610	-2280 ∓ 500	5240 ∓ 610	-8430 ∓ 500
477	4250 ∓ 310	-2780 ∓ 310	5900 ∓ 310	-7700 ∓ 310
565	3920 ∓ 190	-2700 ∓ 220	4640 ∓ 190	-6050 ∓ 220
609	4320 ∓ 50	-3590 ∓ 100	6970 ∓ 50	-7520 ∓ 100
653	6395 ± 50	-5810 ∓ 40	11810 ± 50	-11550 ∓ 40
697	4030 ± 40	-3660 ∓ 25	7990 ± 40	-7880 ∓ 25

SUMMARY OF SPAR CAP STRESSES

CASE 3 & 4. STRESS f psi

BLADE STATION INS.	CASE 3		CASE 4	
	LWR. CAP	UPP. CAP	LWR CAP	UPP. CAP
48	0	0	0	0
81.5	-9410	24830	-2160 ∓ 2110	5750 ± 210
125	-10730	25850	-2020 ∓ 1770	5530 ∓ 40
187.5	-11000	28270	-1770 ∓ 1760	5170 ∓ 660
235	-13610	28350	-1755 ∓ 1410	4690 ∓ 690
301	-14330	25180	-1280 ∓ 1000	3530 ∓ 680
389	-14750	22500	-540 ∓ 610	2320 ∓ 500
477	-14490	19000	150 ∓ 310	1150 ∓ 310
565	-11690	14330	650 ∓ 190	230 ∓ 220
609	-13200	15610	920 ∓ 50	-80 ∓ 100
653	-20010	22350	1450 ± 50	-540 ∓ 40
697	-12200	13680	730 ± 40	-410 ∓ 25

SPAR WEB.

SUMMARY OF SHEAR FLOW & SHEAR STRESS.

CASE 1 & 2.

BLADE STA.	WEB t INS.	CASE 1.		CASE 2.	
		q LB/IN	f_s PSI	q LB/IN	f PSI
48	.250	-199 ∓ 129	- 800 ∓ 510	-402 ∓ 129	- 1610 ∓ 510
81.5 IN'BD	.250	- 181 ∓ 121	- 710 ∓ 470	-424 ∓ 121	1690 ∓ 470
81.5 OUT'BD	.125	58 ∓ 21	465 ∓ 170	131 ∓ 21	1050 ∓ 170
125	.080*	57 ∓ 11	1430 ∓ 270	135 ∓ 11	3380 ∓ 270
187.5	*	73 ∓ 9	1820 ∓ 225	168 ∓ 9	4230 ∓ 225
235.0	*	82 ∓ 7	2050 ∓ 175	186 ∓ 7	4650 ∓ 175
301	*	99 ∓ 5	2470 ∓ 125	216 ∓ 5	5400 ∓ 125
389	*	110 ∓ 3	2750 ∓ 75	230 ∓ 3	5750 ∓ 75
477		139 ∓ 2	1740 —	279 ∓ 2	3490 —
565		123 ∓ 1	1540 —	282 ∓ 1	3520 —
609		170 0	2120 0	327 0	4090 0
653 IN'BD	.080	184 0	2300 0	338 0	4230 0
653 OUT'BD	.125	184 0	1470 0	338 0	3700
697	.125	127 0	1015 0	293 0	2340

* ASSUMED 50% EFFECTIVE TO ALLOW FOR ACCESS HOLES

SPAR WEB.

SUMMARY OF SHEAR FLOW & SHEAR STRESS.

CASE 3 & 4.

BLADE STA.	WEB t INS	CASE 3.**		CASE 4.	
		q LB/IN	f_s PSI	q LB/IN	f PSI
48	.250	+1846	5380	368 ∓ 129	1480 ∓ 510
81.5 IN'BD	.250	+ 1529	6100	350 ∓ 121	1400 ∓ 470
81.5 OUT'BD	.125	− 114	− 910	− 4 ∓ 21	− 30 ∓ 170
125	.080*	− 133	− 3320	− 6 ∓ 11	− 150 ∓ 270
187.5	*	− 229	− 5730	− 4 ∓ 9	− 100 ∓ 225
235	*	− 273	− 6830	2 ∓ 7	− ∓ 175
301	*	− 322	− 8050	8 ∓ 5	200 ∓ 125
389	*	− 438	− 10950	20 ∓ 3	500 ∓ 75
477		− 476	− 5950	37 ∓ 2	465 −
565		− 552	− 6900	59 ∓ 1	740 −
609		− 593	− 7420	57 0	710 0
653 IN'BD	.080	− 600	− 7500	66 0	825 0
653 OUT'BD	.125	− 600	− 4800	66 0	530 0
697.	.125	− 540	− 4320	56 0	450 0

* ASSUMED 50% EFFECTIVE TO ALLOW FOR ACCESS HOLES

** SHEAR IS CORRECTED FOR BLADE TAPER SEE PAGE 3.16

SUMMARY OF TRAILING EDGE STRESS

STRESS IN PSI.

BLADE STATION INS.	DESIGN CASE.				
	1	2	3	4	3 *
48	0	0	0	0	
81.5	1690 ∓ 5110	-17620 ∓ 4870	37020	4820 ∓ 5110	23500
125	1750 ∓ 4630	- 14720 ∓ 4630	32970	4020 ∓ 4630	(21200)
187.5	2060 ∓ 5300	- 17180 ∓ 5330	33930	3570 ∓ 5330	18600
235	1910 ∓ 4580	-16420 ∓ 4580	29780	3390 ∓ 4580	(16000)
301	310 ∓ 3750	-13390 ∓ 3750	21170	1580 ∓ 3750	12100
389	2150 ∓ 2660	- 10700 ∓ 2660	16130	1390 ∓ 2660	7250
477	1950 ∓ 1670	- 7650 ∓ 1670	10100	880 ∓ 1670	
565	2070 ∓ 1160	- 5900 ∓ 1160	5350	670 ∓ 1160	
609	1940 ∓ 950	- 5780 ∓ 950	5200	730 ∓ 950	
653	2050 ∓ 570	- 4250 ∓ 570	4520	840 ∓ 570	
697	1270 ∓ 280	2400 ∓ 280	2450	560 ∓ 280	

* VALUES ARE CORRECTED TO ACCOUNT FOR CHANGE IN SECTION PROPERTIES SEE PAGE 3.15

PREPARED BY [signature] DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.30
CHECKED	TITLE 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED		REPORT NO. 27153

SUMMARY OF TRAILING EDGE SKIN SHEAR FLOW & SHEAR STRESS

CASE 1 & 2.

BLADE STATION INS.	SKIN t INS.	CASE 1		CASE 2	
		q LB/IN	f_s PSI	q LB/IN	f_s PSI
48	.080	30 ∓ 104	375 ∓ 130	379 ± 73	4740 ± 915
81.5 IN'BD	.080	33 ∓ 108	410 ∓ 1350	409 ± 85	5110 ± 1060
81.5 OUT'BD	.040	− 18 ∓ 10	− 450 ∓ 250	− 71 ∓ 10	− 1780 ± 250
125		− 19 ∓ 7	− 475 ∓ 175	− 78 ∓ 7	− 1950 ∓ 175
187.5		− 17 ∓ 5	− 425 ∓ 125	− 66 ∓ 5	− 1550 ∓ 125
235		− 19 ∓ 5	− 475 ∓ 125	− 70 ∓ 5	− 1750 ∓ 125
301		− 16 ∓ 5	− 400 ∓ 125	− 64 ∓ 5	− 1600 ∓ 125
389		− 19 ∓ 6	− 475 ∓ 150	− 72 ∓ 5	− 1800 ∓ 125
477		− 16 ∓ 5	− 400 ∓ 125	− 60 ∓ 4	− 1500 ∓ 100
565		− 13 ∓ 2	− 325 ∓ 50	− 43 ∓ 2	− 1075 ∓ 50
609		− 16 ± 1	− 475 ± 25	− 51 ∓ 1	− 1275 ∓ 25
653.		− 19 ± 1	− 475 ± 25	− 64 ∓ 2	− 1600 ∓ 50
697.	.040	− 11 ± 1	− 275 ± 25	− 50 ± 1	− 1250 ∓ 25

FORM 362B-2

SUMMARY OF TRAILING EDGE SKIN SHEAR FLOW & SHEAR STRESS

CASE 3 & 4

BLADE STATION INS.	SKIN t INS.	CASE 3.		CASE 4.	
		q LB/IN	f_s PSI	q LB/IN	f_s PSI
48	.080	-824	-10300	-126 ± 73	-1580 ± 915
81.5 IN'BD	.080	-868	-10700	-129 ± 85	-1615 ± 1060
81.5 OUT'BD	.040	125	3120	-3 ± 17	-75 ± 425
125		130	3250	4 ± 12	100 ± 300
187.5		119	2980	3 ± 9	75 ± 225
235		130	3250	0 ± 8	0 ± 200
301		116	2900	1 ± 8	25 ± 200
389		146	3630	-4 ± 5	-100 ± 125
477		119	2980	-4 ± 5	-100 ± 125
565		108	2700	-5 ± 2	-125 ± 50
609		120	3000	-4 ± 1	-100 ± 25
653		154	3820	-6 ± 1	-150 ± 25
697	040	144	3600	-4 ± 1	-100 ± 25

PREPARED BY A CHERRITT	DATE 6/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.32
CHECKED		TITLE 100 KW WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

DETAIL ANALYSIS.

THE FOLLOWING PAGES CONTAIN A DETAILED ANALYSIS OF EACH MAJOR COMPONENT OF THE BLADE. ALLOWABLE LOADS OR STRESSES ARE COMPARED WITH THE HIGHEST DESIGN LOADING TO DETERMINE MARGINS OF SAFETY. THE CONTRACT REQUIRES THAT STRESSES DEVELOPED FOR CASE 3 SHOULD NOT BE GREATER THAN YIELD STRESS FOR THE MATERIAL USED AS OBTAINED FROM MIL-HDBK.5B REF. 1. THIS IS ACHIEVED BY QUOTING A MARGIN DIRECTLY ON YIELD OR WHERE MORE CONVENIENT FOR ANALYTICAL PURPOSES A FACTOR OF 1.25 ON ULTIMATE ALLOWABLE IS USED. WHERE CONDITIONS OTHER THAN CASE 3 PRODUCE THE CRITICAL STRESS A FACTOR OF 1.5 ON LIMIT IS USED.

FORM 362B-2

UPPER & LOWER SURFACES (CL1708-1-3)

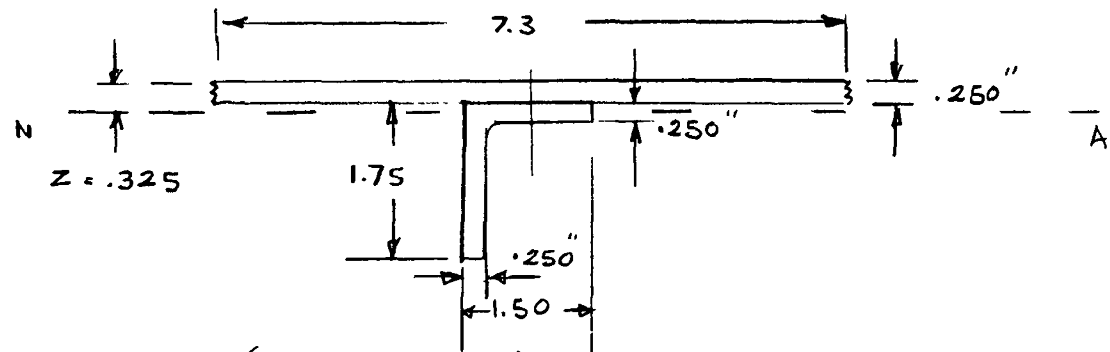
The upper and lower surfaces consist of .250 inch thick skins extending from the blade root at station 48 to station 653. The skins are supported longitudinally by two upper and two lower 0.250 inch thick extruded aluminum stringers and laterally by .080 inch thick ribs at approximately 22 inch spacing. The forward edge of the panels are butt spliced to the .250 inch thick nose skin by means of .250 inch thick aluminum splice plates attached to the upper and lower forward stringers. The aft edge of the panels are attached to the upper and lower .250 inch thick extruded spar cap angles. Chordwise butt splices of both skin and stringers are provided at intervals as dictated by manufacturing and geometric considerations.

The panels are approximately 15 to 17 inches wide between stations 48 - 187.5; they taper to approximately 9 inches wide at station 585 and again to approximately 3.5 inches at station 653. The central panel stringers terminate at station 587 and the forward stringers at station 609. The stringers are angle extrusions with 1.5 inch wide skin attaching flanges and the outstanding flanges are 1.75 inches deep between stations 48 to 389 tapering to 1.28 at station 477 and again to .5 at the termination stations. In the region of station 653 the panels are joined to the outer blade section. The .250 skins are machined out to permit the .125 inch thick nose skin which started at station 611.5 to extend back to the spar. Therefore outboard of station 653 one .125 inch thick skin extends from the upper flange of the spar, around the nose, to the lower flange of the spar and takes place of the separate upper surface, lower surface and nose skins.

Internal loads and stresses for the design cases are shown in Appendix A and the stresses are summarized on pages 3.19 TO 3.31. A detail analysis of panels follows on page 3.34.

UPPER & LOWER SURFACES

TYPICAL INBOARD STRINGER/SKIN ALLOWABLE STA 48-389



MATERIAL:- (MIL-HDBK.5B)

SKIN 2024-T851 PLATE F_{tu} = 67 KSI
F_{ty} = 59 KSI
F_{su} = 38 KSI

STRINGER 2024-T8510 EXTRUSION F_{tu} = 66 KSI
F_{ty} = 58 KSI
F_{su} = 36 KSI

SECTION PROPERTIES.

ITEM	AREA INS^2	Z FROM N.A. INS.	Az^2 INS^4	I_o INS^4
STRINGER	.750	-.4875	.1782	.2158
EFF. SKIN	1.825	.200	.0730	.0095
TOTAL	2.575	.325	.2512	.2253

$I = .2512 + .2253 = .476$ INS^4

$\rho = \sqrt{I/A} = \sqrt{.476/2.575} = \underline{.430 \text{ INS.}}$

MAXIMUM RIB SPACING STA 187.5 - STA 213 = 25.5 INS.

COLUMN ℓ_e (ASSUMING C = 1.0) = 25.5

ℓ/ρ = 59.3

UPPER & LOWER SURFACES

TYPICAL INBOARD STRINGER/SKIN ALLOWABLE STA. 48-389.

COLUMN ALLOWABLE FOR $L/\rho = 59.3$ $E = 10.7 \times 10^6$

$$\pi^2 E/(\ell/\rho)^2 = \frac{\pi^2 \times 10.7 \times 10^6}{59.3^2} = \underline{30000\ psi}$$

THE HIGHEST COMPRESSIVE STRESS OCCURS ON THE LOWER SURFACE FOR CASE 3 (PG 322) = $\underline{19470\ psi}$ AT STA. 235.

IN ADDITION TO THE LONGITUDINAL LOADS THE PANEL IS SUBJECTED TO TRANSVERSE LOADS FROM AERODYNAMIC LOADING TOGETHER WITH CRUSHING LOADS FROM BLADE BENDING CURVATURE.

CRUSHING LOADS ARE GIVEN BY THE EXPRESSION

$$p_c\ LB/IN = \frac{f^2 A}{\bar{Z}\ E}\ LB/IN.$$

f = BEAMWISE BENDING STRESS

A = AREA OF LONGITUDINAL ELEMENT

$\bar{Z}$ = OFFSET OF AREA FROM SECTION NEUTRAL AXIS.

f BEAMWISE ALONE ≈ 21000 psi

$\bar{Z} = 6.92$ (GRID PT 3.) $A = 2.575$

$$\therefore\ p_c = \frac{21000^2 \times 2.575}{6.92 \times 10.7 \times 10^6} = \underline{15.34\ lb/in}$$

THE AERODYNAMIC LOADING IS LESS THAN 1 LB/IN. FOR BOTH UPPER & LOWER SURFACES AT STA 235 AND OPPOSES THE CRUSHING LOAD & WILL, THEREFORE, BE IGNORED. SINCE THE CRUSHING LOADING IS CONTINUOUS THE MAX M WILL BE OVER THE SUPPORTS

$$M = p_c\ \ell^2/12 = \frac{15.34 \times 25.5^2}{12} = \underline{830\ IN\ LBS}$$

UPPER & LOWER SURFACES

TYPICAL INBOARD STRINGER/SKIN ALLOWABLE. STA 48 - 389

BEAM COLUMN MAGNIFICATION FACTOR ON THE BENDING MOMENT (REF. AFFDL-TR-69-42)

$$M = \frac{M}{\left(1 + K\frac{PL^2}{EI}\right)} = \frac{830}{\left(1 - \frac{1}{32}\frac{19470 \times 2.575 \times 25.5^2}{10.7\times10^6 \times .476}\right)} = \underline{1040 \text{ in lb.}}$$

BENDING STRESS IN STRINGER LEG $= -\dfrac{1040 \times 1.675}{476}$ $= \underline{-3660 \text{ psi}}$

THE STRESS IS SMALL FOR COMPRESSION/BENDING INTERACTION.

MARGIN OF SAFETY (COLUMN) $\cdot \left(\dfrac{30000}{19470} - 1\right)$ $= \underline{\underline{.54 \text{ MS.}}}$

THE HIGHEST TENSILE STRESS OCCURS ON THE UPPER SURFACE FOR CASE 3 AT STA 235. $= \underline{23760 \text{ psi}}$

CRUSHING LOADS ARE OF THE SAME ORDER AS FOR THE LOWER SURFACE. HERE, HOWEVER, THE AERODYNAMIC LOADING ADDS TO THE CRUSHING. CONSERVATIVELY USE $15.34 + 1.0 = 16.34$ LB/IN.

MAX M OVER SUPPORTS $= \dfrac{16.34 \times 25.5^2}{12}$ $= \underline{885 \text{ LB.}}$

NEGLECTING TENSION BENDING DEMAGNIFICATION

EXTREME FIBER SKIN STRESS FROM CRUSHING LOADING.

$$f_b = \frac{885 \times .325}{.476} = \underline{600 \text{ psi}}$$

THE 23760 psi TENSILE STRESS IS AT THE STRINGER SKIN NEUTRAL AXIS LOCATION AT 6.75 INS FROM THE SECTION NEUTRAL AXIS POSITION (GRID POINT 9)

EXTREME FIBER STRESS IS CONSERVATIVELY

$$= 23760 \times \left(\frac{6.75 + .325}{6.75}\right) = \underline{24900 \text{ psi}}$$

UPPER & LOWER SURFACES

TYPICAL INBOARD STRINGER/SKIN ALLOWABLE. STA 48-389.

TOTAL EXTREME FIBER TENSILE STRESS

$= 600 + 24900$ $= 25500$ psi

F_{ty} FOR MATERIAL $= 58000$ psi

ALLOWING 25% REDUCTION IN TENSION AREA FOR ATTACHMENT HOLES

$$MS = \left(\frac{58000 \times .75}{25500}\right) - 1 \quad \text{(TENSION)} \quad = .71 \text{ MS.}$$

STRINGERS AT STATION 477. & 565

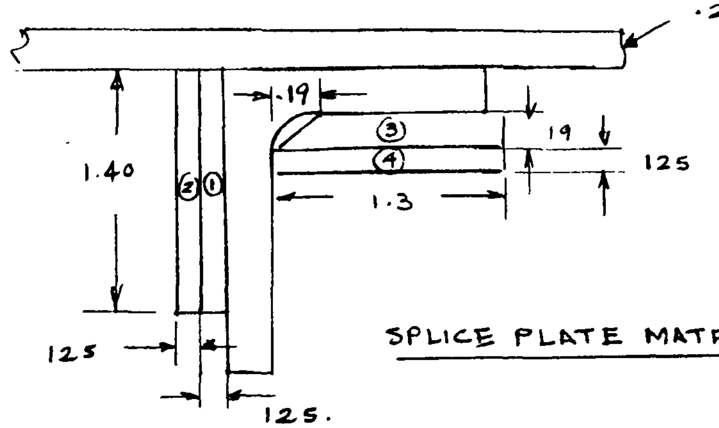
THE STRINGERS AT THESE STATIONS ARE LESS CRITICAL THAN STATION 48-389. THEY ARE ANALYSED IN THE SAME MANNER AS ON THE PRECEDING PAGES AND THE PERTINENT PARAMETERS ARE SHOWN BELOW:-

		STATION	477	565
STRINGER	AREA	INS^2	.6875	.6250
STRINGER	UPRIGHT LEG HEIGHT.	INS	1.50	1.25
STRINGER	I	INS^4	.139	.081
SKIN WIDTH SUPPORTED.		INS	4.5	4.0
$\bar{Z}$ FROM OUTSIDE CONTOUR		INS	.344	.317
RADIUS OF GYRATION ρ		INS	.406	.335
RIB. SPACING. L		INS	22	22
L/ρ			54.2	65.6
F_{cc} COLUMN ALLOWABLE		PSI	35950	24500
COMPRESSIVE STRESS f_c		PSI	16090	12330
LOCAL BENDING STRESS f_b		PSI	3320	3550
MARGIN OF SAFETY.			>1.0	.99.

UPPER & LOWER SURFACES

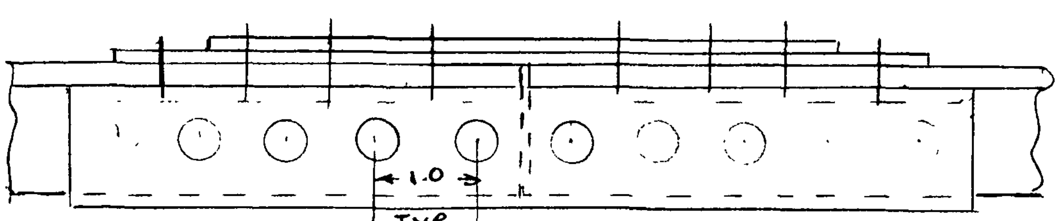
STRINGER SPLICES (CL 1708-1-23.)

THE STRINGERS ARE SPLICED AT A NUMBER OF LOCATIONS ALONG THE BLADE AS SHOWN ON DWG. CL1708-1-23. THE SPLICE IS THE SAME TYPE FOR ALL LOCATIONS, THE STRINGERS ARE BUTTED TOGETHER AND JOINED WITH FLAT ALUMINUM STRAPS ON BOTH LEGS OF THE STRINGER ANGLE AND FASTENED WITH A TOTAL OF 9 1/4" HILOKS EACH SIDE OF THE JOINT. A TYPICAL SPLICE CROSS-SECTION IS SHOWN IN SKETCH BELOW.



SPLICE PLATE MATERIAL 2024-T81.

THE DISPOSITION OF THE SPLICE PLATES IS ARRANGED TO GIVE THE SAME NEUTRAL AXIS AS THE STRINGER TO ELIMINATE OFFSET BENDING STRESSES



SKETCH ABOVE SHOWS THE DISPOSITION OF THE 1/4" HILOKS. THIS TYPICAL SPLICE IS ANALYSED USING THE MAXIMUM

UPPER & LOWER SURFACES

STRINGER SPLICES.

SURFACE STRESS WHICH IS FOR CASE 3
TENSION ON THE UPPER SURFACE (PG 3.21) = 23760 PSI

AREA OF STRINGER. = $.750 \text{ INS}^2$

LOAD IN STRINGER = $.75 \times 23760$ = 17820 LB.

NET AREA OF SPLICE PLATES AT ℄ JOINT
$= (1.4 \times .25 + 1.3 \times .125 + 1.21 \times .19) - .25(.25 + .3125) = .602 \text{ INS}^2$

STRESS ON SPLICE PLATES = $17820/.602$ = 29600 PSI

HIGHEST LOADED ATTACHMENTS ARE THOSE ON THE
$2 \times .125$ SPLICE PLATES IN THE OUTSTANDING STRINGER
LEG. LOAD = $29600[(1.4 - .25) \times .25]$ = 8510 LB

STRENGTH OF 3 1/4 HILOKS IN .250" & 1 IN .125"
2024-T81 = $3 \times 4660 + .3125 \times 1.27$ = 17950 LB.

MARGIN OF SAFETY OF ATTACHMENTS
$= \dfrac{17950}{8510 \times 1.25} - 1$ MS = .69

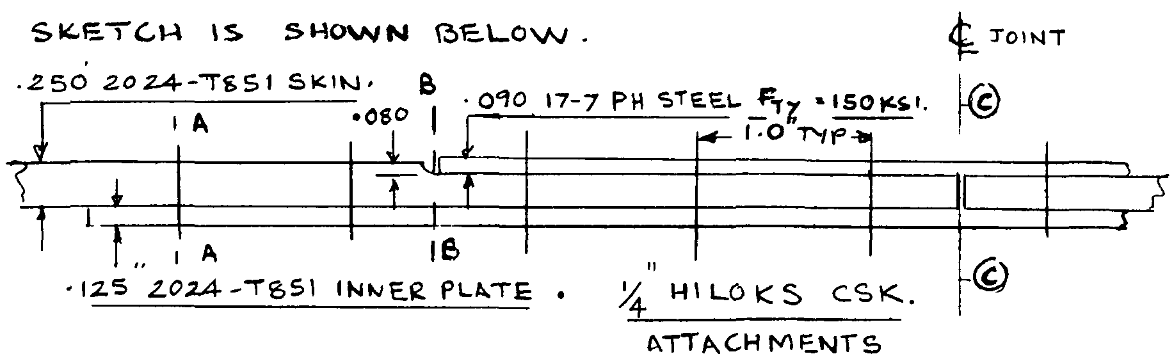
YIELD STRENGTH OF 2024-T81 SPLICE PLATE = 59000 PSI

MARGIN OF SAFETY = $\dfrac{59000}{29600} - 1$ MS = .99

UPPER & LOWER SURFACES

SURFACE SKIN SPLICES

SKIN BUTT SPLICES OCCUR ON THE UPPER SURFACE AT STATIONS, APPOXIMATELY, 187.5, 295, 423.5 & 560 AND ON THE LOWER SURFACE AT 187.5, 317, 450 & 570. THE SPLICES ARE DESIGNED TO PROVIDE MINIMUM ECCENTRICITY WHILE KEEPING WITHIN CONTOUR. THE SKINS ARE BUTTED TOGETHER & JOINED WITH ALUMINUM CHORDWISE BUTT STRAPS ON THE INNER SURFACE, INTERCOSTAL BETWEEN STRINGERS AND WIDE ENOUGH TO PICK UP 5 ROWS OF ATTACHMENTS ON EACH SIDE OF THE BUTT. THE OUTSIDE SURFACES OF THE SKINS ARE MACHINED OUT TO RECEIVE A CONTINUOUS STEEL CHORDWISE BUTT STRAP WIDE ENOUGH FOR 3 ROWS OF ATTACHMENTS EACH SIDE. THE THICKNESSES OF THE BUTT STRAPS ARE DESIGNED TO GIVE NEGLIGIBLE ECCENTRICITY AT THE ℄ OF THE JOINT. A TYPICAL SPLICE IS SHOWN ON DWG. N° CL1708-1-11. THE HIGHEST LOADED SPLICE IS AT STATION 187.5 FOR CASE 3. A CROSS-SECTIONAL SKETCH IS SHOWN BELOW.



THE MAXIMUM STRESS IS IN THE REGION OF THE SPAR CAP. STRESS AT SPAR CAP NEUTRAL AXIS (.40" IN FROM CONTOUR.) PG. 3.26.

= 28270 PSI

UPPER & LOWER SURFACES

SURFACE SKIN SPLICES

CONSERVATIVELY ASSUMING ALL THE STRESS BEAMWISE

BENDING STRESS AT SKIN ℄ $= \dfrac{28270(7.3+.40-.125)}{73}$

$= \underline{29800 \text{ psi}}$

LOADING/CHORDWISE INCH $= 29800 \times .25$ $= \underline{7450 \text{ LB/IN}}$

SURFACE SHEAR FLOW q (GRID PT. 9) $= \underline{287 \text{ LB/IN}}$

CONSIDER SECTION BB. IN THE SKETCH.
AT THIS POINT ASSUME THE .125 INNER SPLICE PLATE FULLY EFFECTIVE.

AXIAL LOADING IN THE PLATE $= \dfrac{7450 \times .125}{.125+(.250-.08)}$ $= \underline{3157 \text{ LB/IN}}$

THE SHEAR LOADING IS RELATIVELY SMALL AND IS ASSUMED TAKEN 100% BY THE OUTER STEEL PLATE WHICH IS CONTINUOUS CHORDWISE.

STRENGTH/IN OF 2 ROWS OF 1/4" HILOKS IN .125 PLATE AT MAX. 1.3 SPACING. $= \dfrac{3125 \times 2 \times 1.08}{1.3} = \underline{5190 \text{ LB/IN}}$

MARGIN OF SAFETY $= \dfrac{5190}{3157 \times 1.25} - 1$ $\underline{\underline{MS = .32}}$.

CENTROID FROM CONTOUR SECTION AA $\underline{.125 \text{ INS}}$

" " " " BB $\underline{.2275 \text{ INS}}$

OFFSET BENDING MOMENT $= 3157(.2275-.125)$ $= \underline{324 \text{ INLBS/IN}}$.

FIXING MOMENT AT AA & BB $= 324/2$ $= \underline{162 \text{ INLBS/IN}}$.

THIS MOMENT CAN BE TAKEN BY THE OVERALL STRINGER/SKIN AND SPAR CAP/SKIN COMBINATION. PRELIMINARY ANALYSIS SHOWS THE RESULTING BENDING STRESS TO BE IN THE ORDER OF 1200 psi. THIS LOAD PATH, HOWEVER, DOES REQUIRE THE SKIN.

UPPER & LOWER SURFACES

SURFACE SKIN SPLICES.

TO TAKE TORSION. FOR THIS ANALYSIS CONSERVATIVELY 50% OF THE MOMENT LOADING WILL BE ASSUMED TAKEN BY THE SKIN & SPLICE PLATES.

STRESS IS MAXIMUM AT SECTION AA.

TENSION EFFICIENCY OF SKIN WITH MINUMUM ATTACHMENT SPACING OF 1.10" (CSK) η = .75

STRESS AT AA (MAX. IN SKIN.)

$$f_t = \frac{7450}{.25 \times .75} + \frac{162 \times 6}{.25^2 \times .75 \times 2} = 39700 + 10400 \qquad \underline{50100\,psi}$$

F_{Ty} OF SKIN = $\underline{59000\,psi}$

MARGIN OF SAFETY $= \frac{59000}{50100} - 1$ $\quad$ MS = .18

SECTION CC IN SKETCH

CENTROID OF 090 17-7 PH STEEL STRAP & THE .125 ALUMINUM PLATE FROM CONTOUR

$$= \frac{.09 \times 29 \times .035 + .125 \times (.250 \times .0625) \times 10.5}{.09 \times 29 + .125 \times 25} = \underline{.1278\ INS}$$

I.E OFFSET AT BB IS .1278 − .1250 = .0028 (NEGLIGIBLE)

THE 162 LB/IN FIXING MOMENT AT BB WILL, HOWEVER, CARRY ACROSS SECTION CC

∴ TOTAL AXIAL LOAD IN .090 STEEL PLATE

$$= \frac{7450}{2} + \frac{162 \times .5}{(.1704 \cdot .045 + .0625)} = 3725 + 292 = \underline{4017\ LB/IN}$$

SHEAR FLOW IN SKIN ASSUME TAKEN FULLY BY THE .090 STEEL PLATE = $\underline{287\ LB/IN}$

$$= \sqrt{4017^2 + 287^2} = \underline{4027\ LB/IN}$$

UPPER & LOWER SURFACES

SURFACE SKIN SPLICES

SECTION CC.

TOTAL AXIAL LOAD IN .125 INNER PLATE

$= \frac{7450}{2} - 292 \qquad = \underline{3433 \text{ LB/IN}}$

THE FIRST TWO ROWS OF ATTACHMENTS WERE ASSUMED TO PUT IN 3157 LB/IN (PAGE 3.41)

FOR THE PURPOSES OF CONSERVATIVELY ESTIMATING THE LOADS ON THE INNER THREE ROWS OF ATTACHMENTS ASSUME THE INNER THREE ROWS TAKE:-

$\frac{3433 \times 3}{5} \qquad = \underline{2060 \text{ LB/IN}}$

∴ TOTAL LOAD ON 3 ROWS OF 1/4 HILOKS BEARING IN THE .170 MACHINED DOWN SKIN $= 2020 + 4017 \qquad = \underline{6037 \text{ LB/IN}}$

STRENGTH OF ATTACHMENTS AT MAX. 1.3" SPACING

$= \frac{4250 \times 1.08 \times 3}{1.3} \qquad = \underline{10590 \text{ LB/IN}}$

MARGIN OF SAFETY $= \frac{10590}{6037 \times 1.25} - 1 \qquad \underline{\underline{MS = .40}}$

TENSION EFFICIENCY IN .090 STEEL PLATE WITH 1/4" HILOKS AT MINIMUM SPACING = 1.10 $\qquad = .73.$

MAX. STRESS IN STEEL PLATE $= \frac{4027}{.09 \times .73} \qquad = \underline{61300 \text{ psi}}$

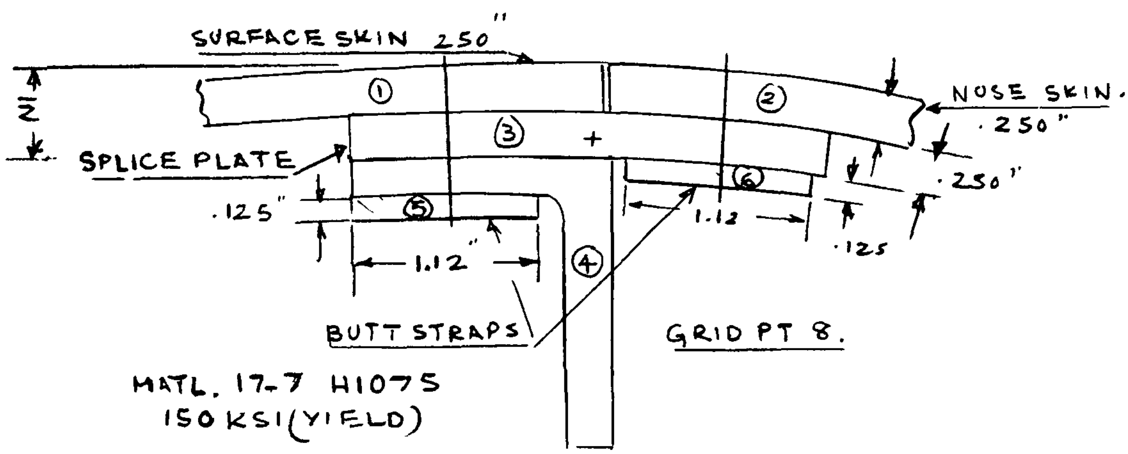
F_{TY} OF 17-7 PH SHEET COND. TH 1075 $\qquad = \underline{150000 \text{ psi}}$

MARGIN OF SAFETY $\qquad \underline{\underline{MS > 1.0}}$

UPPER & LOWER SURFACES

NOSE SKIN SPLICE PLATE JOINTS. (CL 1708-1-23.)

THE SPLICE PLATES BETWEEN THE NOSE SKIN AND THE UPPER & LOWER SURFACE SKINS ARE BUTT JOINED AT STATIONS 158, 269, 400 & 532. SINCE IT IS NOT POSSIBLE TO SPLICE THESE PLATES INTERNALLY WITHOUT INDUCING AN OFFSET BENDING MOMENT FLAT STEEL BUTT STRAPS WERE USED TO MINIMIZE THE ECCENTRICITY. A TYPICAL CROSS SECTION OF THE SPLICES IS SHOWN BELOW.



AS SHOWN IN THE DIAGRAM THE SPLICE PLATE TO BE JOINED IS SANDWICHED BETWEEN THE FORWARD STRINGER AND THE SURFACE SKINS. TWO STEEL BUTT STRAPS POSITIONED AS SHOWN ARE EACH ATTACHED WITH 4 1/4" HILOKS EACH SIDE OF THE SPLICE JOINT. THE TOTAL SECTION WITH STRINGER BUTT STRAP & EFFECTIVE SKIN WILL TAKE THE LOAD FROM THE SPLICE PLATE.

PROPERTIES JUST OUTSIDE OF JOINT AREA. ITEM ① ② ③ & ④

$A = 3.13\ IN^2$, $\bar{Z} = .493\ IN$, $I = .526\ INS^4$

PREPARED BY	DATE	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE
A. Blewitt	6/75		3.45
CHECKED		TITLE: 100 KW WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

UPPER & LOWER SURFACES

NOSE SKIN SPLICE PLATE JOINTS.

PROPERTIES AT JOINT ℄ ITEMS ① ② ④ ⑤ & ⑥

EQUIVALENT ALUMINUM $E_S/E_A = 29/10.5 = 2.76$

$A_{EQ} = 3.21 \text{ IN}^2 \quad \bar{Z} = .566 \quad I = .640 \text{ INS}^4$

THE HIGHEST LOADED JOINT IS AT STA 158. LOADS ARE OBTAINED FROM THE NEAREST CALCULATED STATION 187.5 MAXIMUM STRESS IS FOR CASE 3 (GRID PT. 8)

STRESS $= -18121 - 2243 \qquad = \underline{-20360 \text{ PSI}}$

TOTAL LOAD ON STRINGER/SKIN AREA JUST OUTSIDE OF JOINT $= 3.13 \times 20360 \qquad = \underline{-63730 \text{ LB.}}$

MOMENT FROM ECCENTRICITY

$= 63730(\underbrace{.566 - .493}_{.073}) \qquad = \underline{4650 \text{ IN LBS.}}$

FIXING MOMENT $= 2990/2 \qquad = \underline{2325 \text{ IN LBS}}$

(THIS GIVES A TENSION IN THE SKIN EACH SIDE OF THE JOINT AND COMPRESSION IN THE SKIN AT THE JOINT ℄).

CONSIDER SECTION AT JOINT ℄

COMPRESSIVE STRESS $= \dfrac{63730}{3.21} = \underline{19850 \text{ PSI}}$

MAX LOADED STEEL BUTT STRAP IS ITEM ⑥ ON THE SKETCH. $\bar{Z}$ OF ⑥ $= .58$

STRESS FROM BM. ON ⑥ $= \dfrac{2325 \times (.58 - .566)}{.640} = 50 \text{ PSI}$ IGNORE

AREA OF ⑥ $1.12 \times .125$ (STEEL) $= \underline{.140}$

LOAD IN BUTT STRAP ⑥ $= .140 \times 19850 \times 2.76 \qquad = \underline{7670 \text{ LB.}}$

FORM 362B-2

UPPER & LOWER SURFACES.

NOSE SKIN SPLICE PLATE JOINTS.

STRESS IN STEEL BUTT STRAP (6) = $7670/.14$ = 54800 psi

MARGIN OF SAFETY OBVIOUSLY MS > 1.0

STRENGTH OF 4 1/4" HILOKS IN .125 STEEL OR
250 ALUMINUM = 4660 x 4 = 18640 LB

MARGIN OF SAFETY ON ATTACHMENTS MS > 1.0

TOTAL STRESS IN THE SKIN AT THE ℄ JOINT
($\bar{z}$ SKIN = .125")

$$f_t = 19850 + 2325 \times \left(\frac{\overset{1600}{.566 - .125}}{.640}\right) = 20450 \text{ psi}$$

MARGIN OF SAFETY IN SKIN MS > 1.0

TOTAL STRESS AT BOTTOM OF STRINGER LEG
OUTSIDE OF JOINT $\bar{z}$ = 2.25

$$= -20360 - 2325 \left(\frac{2.25 - .493}{.526}\right) = 28130 \text{ psi}$$

MARGIN OF SAFETY, STRINGER MS > 1.0.

UPPER & LOWER SURFACES

PANEL ATTACHMENTS.

1) ATTACHMENTS TO SPAR CAP. STA 81.5 OUT'BD

ATTACHMENT WITH 1/4" HILOKS CSK. IN THE .250 SKIN AT 2.2 INCH SPACING STRENGTH $= \frac{4660}{2.2} = \underline{2118 \text{ LB/IN}}$

MAXIMUM SHEAR FLOW q CASE 3 AT STA 609 $= \underline{500 \text{ LB/IN}}$

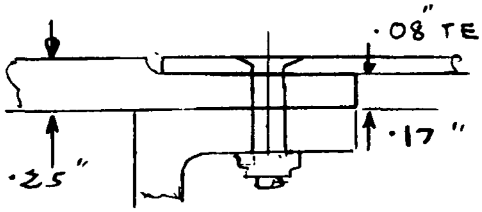
MARGIN OF SAFETY $\underline{\underline{MS > 1.0.}}$

2) ATTACHMENT TO LE. SPANWISE SPLICE 81.5 OUT'BD

ATTACHMENTS ARE THE SAME AS FOR (1) ABOVE

MS $\underline{MS > 1.0}$

3) ATTACHMENT TO SPAR CAP STA 48 TO 81.5



ATTACHMENT WITH 3/16" HILOKS AT 1.0" SPACING THESE ATTACHMENTS ALSO PICK UP THE TRAILING EDGE SKIN

MAXIMUM SHEAR FLOW IS FOR CASE 3 = 2648 LB/IN OF THIS SHEAR FLOW 868 LB/IN GOES INTO THE TRAILING EDGE SKIN & 1780 LB/IN. INTO THE SPAR CAP. SINCE THE EFFECTIVE SPAR CAP AREA INCLUDES THE .25" SKIN MUCH OF THE 1780 LB/IN STAYS IN THE SKIN. HOWEVER, IT IS CONSERVATIVELY ASSUMED TO GET TAKEN BY THE SPAR CAP ANGLE.

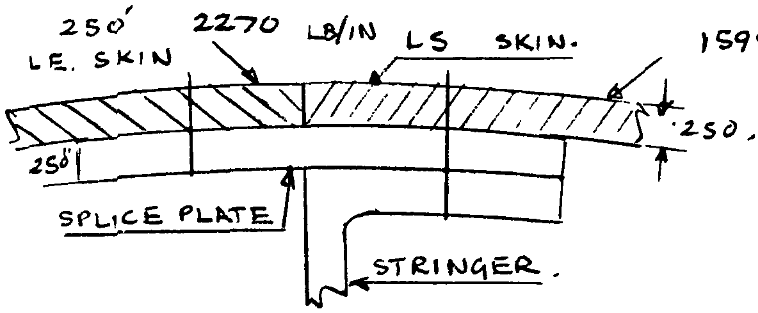
UPPER & LOWER SURFACES

PANEL ATTACHMENTS

STRENGTH OF 3/16 HILOKS BEARING IN .170 ALUMINUM.
SKIN = 1.08 x 3230 = 3488 LB/IN.

MARGIN OF SAFETY IN SKIN $= \left(\dfrac{3488}{2648 \times 1.25}\right) - 1$ MS = .05

4) ATTACHMENT TO LE SPANWISE SPLICE STA 48-81.5



ATTACHMENTS EACH SIDE OF SPLICE ARE 1/4" HILOKS
2.0 INCH AVERAGE SPACING, STRENGTH = 2330 LB/IN

SHEAR FLOWS FOR THE MAXIMUM DESIGN CONDITION
CASE 3

℄ UPPER SURFACE GRIDPOINT 8 AT STATION 48 = 1598 LB/IN

℄ NOSE SKIN GRID POINT 7 AT STA 81.5 INB'D = 2270 LB/IN

APROXIMATELY 300 LB/IN OF THIS SHEAR FLOW STAYS IN THE NOSE SKIN AS ITS SHARE OF THE STRINGER/SKIN COMBINATION AXIAL LOAD. THE 160-180 KSI ALLOY STEEL USED FOR THE HIGHLOKS HAS A YIELD VALUE 90% OF ULTIMATE. THERFORE THE MARGIN OF SAFETY ON YIELD FOR THESE ATTACHMENTS IS

$$MS = \frac{.9 \times 2330}{(2270-300)} - 1 \qquad MS = .06.$$

UPPER & LOWER SURFACES

PANEL ATTACHMENTS.

ATTACHMENT TO STA. 48 RIB.

ATTACHMENT TO RIB FLANGE WITH 2 ROWS OF CSK. 1/4" HILOKS IN .250 SKIN AT MAX. SPACING 1.50

STRENGTH = $2 \times 4660 / 1.5$ = 6213 LB/IN.

MAXIMUM SHEAR FLOW, CASE 3 = 2159 LB/IN

M.S. MS. > 1.0

ATTACHMENT TO STA. 81.5 RIB.

ATTACHMENT TO RIB FLANGE WITH 3/8" HILOKS. CSK IN .250 SKIN. AT MAX 1.5" SPACING.

STRENGTH = $9985/1.5$ = 6657 LB/IN

THESE ATTACHMENTS ALSO TAKE CENTRIFUGAL FORCE THROUGH THE RIB TO THE ROOT ATTACHMENT EXTENSION. THIS LOAD, HOWEVER, IS SMALL

IE $940 \times .25 \times 1.5$ = 353 LB/ATTACHMENT & IS THEREFORE NEGLECTED.

MAXIMUM SHEAR FLOW FROM 81.5 RIB REACTION LOADS FOR CASE 3 = 2332+401 = 2733 LB/IN.

M.S. MS. > 1.0

LEADING EDGE SKIN PANEL. (CL1708-1-23.)

MATL. 2024-T351 PLATE .250" t. $F_{tu} = 65$ KSI

$F_{su} = 38$ KSI

$F_{cy} = 40$ KSI

2024-T81 SHEET .125" t $F_{tu} = 67$ KSI

$F_{su} = 40$ KSI

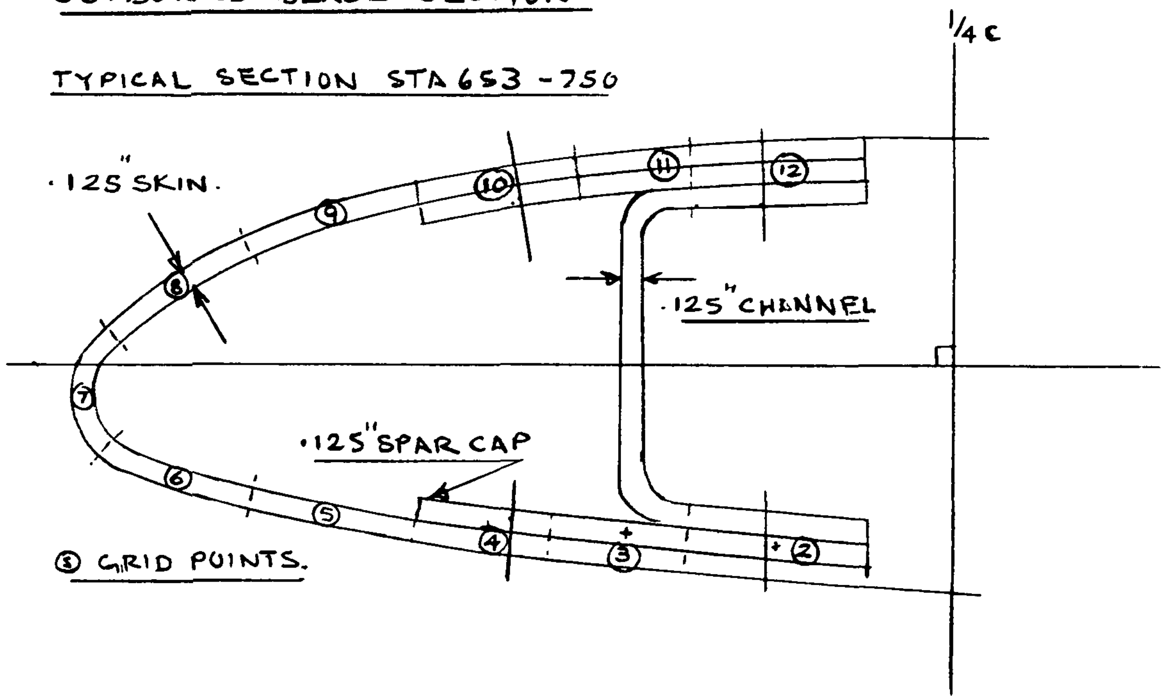
$F_{cy} = 59$ KSI

THE LEADING SKIN WRAPS AROUND THE BLADE NOSE FROM THE UPPER FORWARD TO THE LOWER FORWARD STRINGER FROM STA. 48 TO STA. 653. OUTBOARD OF STA. 653 IT EXTENDS BACK TO THE OUTBOARD CHANNEL SECTION SPAR AND BECOMES THE WHOLE 'D' SECTION CLOSURE OF THE OUTER BLADE. THE THICKNESS REMAINS CONSTANT AT .250" FROM STATION 48 TO STATION 611.50 WHERE MANUFACTURING CONSIDERATIONS REQUIRED REDUCTION TO .125" THICKNESS WHICH REMAINS CONSTANT TO STA 750. THE DEVELOPED STRESSES ARE GENERALLY LOWER THAN THE UPPER & LOWER PANEL STRESSES & THE HIGH DEGREE OF CURVATURE PROVIDES A GREATER STABILITY. IN VIEW OF THIS, DETAIL ANALYSIS WILL ONLY BE MADE FOR THE .125 t OUTBOARD BLADE SECTION WHICH IS NOT COVERED BY THE UPPER & LOWER PANEL ANALYSES. SINCE THE MASS BALANCE REQUIREMENTS NECESSITATE LEADING EDGE BALANCE WEIGHTS, THE THICK LEADING EDGE SKIN SERVES AS STRUCTURAL BALLAST & PROVIDES A HIGH TORSIONAL STIFFNESS. AN ANALYSIS OF THE OUTER BLADE SECTION IS SHOWN ON THE FOLLOWING PAGE. (3.51)

LEADING EDGE SKIN PANEL (CL1708-1-23)

OUTBOARD BLADE SECTION

TYPICAL SECTION STA 653 - 750



THE MAXIMUM STRESS ON THE OUTER BLADE SECTION IS FOR CASE 3 AT STATION 653.

MAXIMUM TENSILE STRESS UPPER SURFACE (12) = 22350 psi

$\bar{Z}$ TO ELEMENT NEUTRAL AXIS = 1.62 INS

$\bar{Z}$ TO OUTSIDE SKIN SURFACE = 1.81 INS

MAX STRESS (ASSUMING ALL STRESS IS BEAMWISE BENDING)

$$= 22350 \times \frac{1.81}{1.62} \qquad = 24970 \text{ psi}$$

MARGIN OF SAFETY ON YIELD WITH A 75% TENSION EFFICIENCY FACTOR $= \left(\frac{59000 \cdot .75}{24970}\right) - 1$ $\quad$ MS = .77

COMPRESSIVE ALLOWABLE OF PANEL.

CHECK LOWER SURFACE PANEL BETWEEN THE LEADING EDGE BACK TO THE SPAR CHANNEL ATTACHMENT NEGLECTING THE STIFFENING EFFECT OF THE SPAR CAP.

LEADING EDGE SKIN PANEL.

OUTBOARD BLADE SECTION

PANEL WIDTH $b = 5''$ $t = .125$ $b/t = 40$

CURVATURE RADIUS 25 INS. $t/r = .005$

FROM SM.33 K FLAT PANEL = 3.62

K_1 FOR CURVATURE = 33.

$$b/t_e = \sqrt{\frac{1}{\frac{3.6^2}{40^2} + .33 \times .005}} = 16$$

F_{CR} = 39000 psi

MAXIMUM COMPRESSIVE STRESS IS AT GRID POINT 2, CASE 3. = 20010 psi

MARGIN OF SAFETY $= \frac{39000}{20010 \times 1.25} - 1.$ MS = .56

ATTACHMENTS.

THE ATTACHMENT OF THE LEADING EDGE SKIN PANEL TO THE SPAR CAP IS WITH 3/16" HILOKS CSK. IN .125" SKIN AT 2.2 INCH SPACING.

STRENGTH (LR 20159) YIELD $= 1680/2.2$ = 764 LB/IN

MAX. SHEAR FLOW IN SPAR IS FOR CASE 3

q (PAGE 3.28) = 540 LB/IN

MS $= (764/540) - 1$ MS. = .41

ATTACHMENT OF LEADING EDGE SKIN TO SPAR CAP IS WITH 3/16" HILOKS AT 2.2" SPACING

STRENGTH (YIELD.) = 764 LB/IN

MAX. q FOR CASE 2 & 3 = 255 LB/IN

M.S. ON YEILD. $= (764/255) - 1$ MS > 1.0

SPAR WEB. (DWG CL 1708-1-19) STA 48-652

MATL. 2024-T81 CLAD MIL. HDBK 5B

-105, -107, -109, & -111 $t = .080$ } $F_{tu} = 67$ KSI, $F_{su} = 39$ KSI, $F_{cy} = 57$ KSI

MATL. 2024-T851 BARE

-101 $t = .250$ $F_{tu} = 67$ KSI, $F_{su} = 40$ KSI, $F_{cy} = 59$ KSI

MATL. 2024-T62

-103 (& CL 1708-1-3-175) $t = .125$ $F_{tu} = 62$ KSI, $F_{su} = 37$ KSI, $F_{cy} = 49$ KSI

THE SPAR WEB IS .250" t PLATE BETWEEN STA 48 & 81 AND IS CURVED TO CLEAR THE ROOT END ATTACHMENT PIPE. THE CURVE TAPERS OUT TO ZERO STA. 81-101 WITH A .125" t PLATE. A FLAT WEB .080" t EXTENDS FROM STA. 101 TO STA. 652. THE OUTER BLADE SPAR CHANNEL (DWG CL1708-1-3-175) IS ATTACHED TO THE .080 WEB AND EXTENDS FROM STA 652 TO 750. THE SPAR WEB IS STIFFENED BY THE .080 LEADING EDGE RIBS AT 22 IN SPACING. THE .040 TRAILING EDGE RIBS ARE NOT CONSIDERED AS PROVIDING SUPPORT FOR SHEAR BUCKLING. FLANGED LIGHTENING HOLES ARE PROVIDED FOR MANUFACTURING ACCESS FROM STA. 110 TO 389. THE ANALYSIS ON THE FOLLOWING PAGE SHOWS THAT THE WEB IS SHEAR RESISTANT.

PREPARED BY A. CHERRITT	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.54
CHECKED		TITLE 100 KW WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

SPAR WEB

BUCKLING STRESS SM 33

① BLADE STA. (INS.)	② b (INS.)	③ a (INS.)	④ t (INS.)	⑤ b/t	⑥ b/a	⑦ $\sqrt{K_s}$ SHEAR	⑧ $\frac{b}{t\sqrt{K_s}}$	⑨ SHEAR F_{cr} BUCKLING (P.S.I.)	⑩ q_b ⑨×④ (LB/IN.)	⑪ MAX. q COND 3. (LB/IN)
48 – 81.5	20.5	33	.250	8	.62	2.51	3	30000*	7500	1846
81.5 OUTBD	19.5	22	.125	156	.88	2.74	57	3200	400	-114
125	14.7	17	.080	184	.86	3.50	52	3800	304	-133
187.5	13.0	14.7		163	.88	3.55	46	4700	376	-229
235	11.7	22		146	.53	3.23	45	5000	400	-273
301	9.5	22		119	.43	3.16	38	6600	528	-322
389	7.0	22		88	.33	2.98	29.5	11500	920	-438
477	4.8	22		60	.22	2.55	23.5	18500	1480	-476
565	2.8	22		35	.13	2.25	15.5	28500*	2280	-552
609	2.0	22		25	.09	2.24	11	29000	2320	-593
653 INBD	1.4	22	.080	18	.06	2.22	8	29000*	2320	-600
653 OUTBD	2.8	62	.125	23	.045	2.20	10.5	27000	3375	-540

SPAR WEB

① BLADE STA.	⑫ F_S ALL.	⑬ f FOR HOLES	⑭ q ALL ④⑫⑬	⑮ MS ⑭/⑪1.25 −1
INS	PSI		LB/IN.	
48 } 81.5 }	30000	1.0	7500	2.2
81.5	28000	1.0	3500	HIGH
125	29000	.70	1624	
187.5				
235				
301				HIGH
389		.70	1624	1.97
477		1.0	2320	2.90
565				2.26
609				2.13
653 INBD	29000		2320	1.09
653 OUT'BD	28000	1.0	3500	HIGH

SPAR WEB JOINTS, & ATTACHMENTS. (MIL.HNDBK. 5.) CL1708-1-19 & SM 79.

1) ATTACHMENT TO STA. 48 RIB FLANGE.

1/4" HILOKS AT 1.0" SPACING. IN .250 WEB

UTLIMATE q ALLOWABLE = 4660 LB/IN

DESIGN SHEAR FLOW CASE 3 (PG 3.28) = 1846 LB/IN.

MS > 1.0.

2) ATTACHMENT TO STA. 81.5 RIB FLANGE.

HERE 6 7/16 BOLTS PICK UP THE SPAR WEB THE 81.50 RIB & THE ROOT EXTENSION EXTENSION + 9 1/4"

SPAR WEB.

ATTACHMENT TO STA 81.5 RIB FLANGE

HILOKS THROUGH THE RIB FLANGE & SPAR WEB.

TOTAL STRENGTH $= 9 \times 4660 + 6 \times .87 \times 10940 = \underline{99000 \text{ LB.}}$

SHEAR LOAD $= 21.16 \times 1846 = \underline{39060 \text{ LB.}}$

THIS ATTACHMENT IS ALSO USED AS A "FAIL SAFE" CENTRIFUGAL FORCE PATH. C.F. TOTAL $= \underline{24400 \text{ LB.}}$

RESULTANT LOAD $= \sqrt{24400^2 + 39060^2} = \underline{46050 \text{ LB}}$

$MS = \left(99000 / 46050 \times 1.25 \right) - 1 = \underline{\underline{.72}}$

3) STA 48-81.5 CENTER JOINT.

THE .250 WEB BETWEEN STA 48 & 81.5 IS SPLIT ALONG THE CENTER FOR MANUFACTURING CONSIDERATIONS AND IS SPLICED WITH A .250 BUTT STRAP WITH 1/4" HILOKS AT MAX. 1.2 SPACING ONE ROW EACH SIDE

STRENGTH / IN $= 4660 / 1.2 = \underline{3880 \text{ LB/IN}}$

$MS = \left(3880 / 1554 \times 1.25 \right) - 1 = \underline{\underline{1.0}}$

THE FIRST 8 ATTACHMENTS IN EACH SIDE OF THE SPLICE ARE 3/8 BOLTS WHICH ALSO ATTACH TO THE ROOT ATTACHMENT EXTENSION TO TAKE THE FAIL SAFE CENTRIFUGAL FORCE LOAD.

LOAD ON ONE SIDE $= 24400/2 + 1554 \times 8.8 = \underline{25900 \text{ LB.}}$

STRENGTH OF 6 3/8" BOLTS IN .250

$= 6 \times .87 \times 9375 = \underline{48900 \text{ LB.}}$

$MS = \left(48900 / 25900 \times 1.25 \right) - 1 = \underline{\underline{.51}}$

SPAR WEB.

4) ATTACHMENT TO SPAR CAPS STA 48 TO 81.5

STRENGTH OF 1/4" HILOKS AT MAX 1.2" SPACING IN .250 WEB

$q_{ALL} = 4660/1.2 \qquad = \underline{\underline{3883\ LB/IN}}$

THESE ATTACHMENTS ALSO SERVE AS A CENTRIFUGAL FORCE "FAIL SAFE" LOAD PATH FROM THE SPAR CAPS TO THE SPAR WEB THROUGH THE OUTER CENTER JOINT BOLTS TO THE ROOT ATTACHMENT EXTENSION

LOAD/IN $= 24400/(2 \times 33) = 370$ LB/IN.

TOTAL APPLIED LOADING $= 370 + 1846 \qquad = \underline{2216\ LB/IN}$

$MS = \left(\frac{3883}{2216 \times 1.25}\right) - 1 \qquad = \underline{\underline{.40}}$

5) .125 WEB TO STA 81.5 RIB.

ATTACHMENT WITH 1/4" HILOKS AT 1.3" MAX. SPACING

STRENGTH IN .125 $= 3125 \times 1.18/1.3 \qquad = \underline{2836\ LB/IN}$

q FOR CASE 3 $= \qquad = \underline{114\ LB/IN}$

LOADING FROM AXIAL STRESS IN SPAR CAP IN UPPER RIVETS @ $22000 \times .08 \qquad = \underline{1760\ LB/IN}$

RESULTANT ATTACHMENT LOADING $= \sqrt{1760^2 + 114^2} = \underline{1764\ LB/IN}$

MARGIN OF SAFETY $= \left(2836/1764 \times 1.25\right) - 1 \qquad \underline{\underline{MS = .28}}$

6) .080 WEB TO SPAR CAPS. STA 101 TO 652.

ATTACHMENT WITH 1/4" HILOKS AT 1.2" MAX. SPACING

STRENGTH $= \frac{2000 \times 1.22}{1.2} \qquad = \underline{2033\ LB/IN}$

MAX. q CASE 3 (PG. 3.28) $\qquad = \underline{600\ LB/IN}$

MARGIN OF SAFETY $\qquad \underline{\underline{MS > 1.0}}$

SPAR WEB.

WEB JOINTS

THE SPAR WEB IS BUTT SPLICED WITH .080 2024-T3 BUTT STRAPS AT STATIONS 104, 245, 386 & 530

TYPICAL SPLICE ATTACHMENT WITH 2 ROWS OF 3/16 HILOKS AT MAXIMUM SPACING 1.25 INS.

STRENGTH. $= \dfrac{1520 \times 2 \times 1.08}{1.25} = 2626$ LB/IN

MAX. LOADING IS FOR CASE 3 INTERPOLATING BETWEEN STATIONS 235 & 301.

WEB SHEAR FLOW q = 280 LB/IN

AXIAL LOADING ON UPPERMOST RIVETS FROM SPAR STRESS $\approx 22000 \times .08$ = 1760 LB/IN

RESULTANT LOADING $= \sqrt{1760^2 + 280^2}$ = 1782 LB/IN

MS $= \left(\dfrac{2626}{1782 \times 1.25}\right) - 1$ MS. = .18

TRAILING EDGE SKIN PANELS (1708-1-24)

MATL. 2024-T81 CLAD. $F_{tu} = 64$ KSI $F_{cy} = 57$ KSI.

$F_{su} = 38$ KSI.

THE TRAILING EDGE SKIN PANELS ARE SHOWN ON DWG Nº CL1708-1-23, AS FOLLOWS

DWG DASH Nº. UPPER	DWG DASH Nº. LOWER	t INS	BLADE LOCATION STA - STA. INS.	DESIGN CONDITION SHEAR FLOW LB/IN 1	2	3
-161	-181	.080	48 - 88.25	14 ±99	360 ±95	-868
-163	-183	.040	88.25 - 220.25	19 ±5	72 ±5	146
-165	-185	.040	220.25 - 352.25			
-167	-187	.040	352.25 - 484.25			
-169	-189	.040	484.25 - 616.25	19 ±1	64 ±1	154
-171	-191	.040	616.25 - 750.00			

THE SKIN PANELS ARE SUPPORTED BY $t = .040$ RIBS AT APPROXIMATELY 14 TO 18" SPACING.

OUTER PANELS (484.25 - 750.00) INITIAL BUCKLING (SM 33)

PANEL SIZE $a = 18.5$ $b = 15.7$ $t = .040$

$b/t = 393$ $b/a = .85$ $\sqrt{K} = 3.46$

$b/t_c = 393/3.46 = 113$ $F_{CR} = 850$ psi

$q_b = 850 \times .04 = .34$ LB/IN $= \underline{34 \text{ LB/IN}}$

MAX DESIGN q (COND 3) $= \underline{154 \text{ LB/IN}}$

$f_s = 154/.040 = \underline{3850 \text{ PSI}}$

FORM 362B-2

TRAILING EDGE SKIN PANELS

OUTER PANELS (CONT'D)

$q/q_b = 154/34 = 4.5$

DIAGONAL TENSION FACTOR (NACA TN 2661 FIG 13) $k = .33$

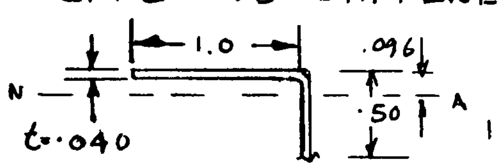
ALLOWABLE ULT. SHEAR STRESS (FIG 19) $F_S = 28500$ psi

ALLOWABLE ULT. SHEAR FLOW $= 28500 \times .04 = \underline{1140 \text{ LB/IN}}$

M.S. FOR WEB IS OBVIOUSLY >1.0 MS > $\underline{1.0}$

THE .040 TRAILING EDGE RIBS STIFFEN THE PANELS.

EFFECTIVE STIFFENER PROPERTIES (NACA TN 2661)



$A_U = .06 \text{ ins}^2$

$I = .00112 \text{ ins}^4$

$\rho = \sqrt{\frac{.06}{.00112}} = .137$ $\quad A_{Ue} = \frac{.06}{1 + \left(\frac{.096}{.137}\right)^2} = \underline{.040 \text{ ins}^2}$

MAX. STIFFENER STRESS FIG 14 & 15

$A_{Ue}/dt = .04/.04 \times 15.7 = .064$ $\quad \sigma_U/\tau = .68$

$d/h_U = 15.7/18.5 = .85$ $\quad \sigma_{U\,MAX.}/\sigma_U = 1.16$

MAX. STIFFENER STRESS $f_c = 1.16 \times .68 \times 3850 = \underline{3036 \text{ psi}}$

ALLOWABLE STRESS FOR FORCED CRIPPLING (F_o)

FIG. 20 $t_U/t = 1.0$ $\quad F_o = \underline{15500 \text{ psi}}$

ANGLE OF DIAGONAL TENSION FIG 16a

TAN $\alpha = .83$ $\quad \alpha = 39.7°$

MS FOR T.E. RIB FORCED CRIPPLING MS > $\underline{1.0}$

TRAILING EDGE SKIN PANELS

OUTER PANELS (CONTD.)

PANEL ATTACHMENTS

a) ATTACHMENT TO SPAR.

ATTACHMENT TO SPAR IS WITH 1/8 LOW HEAD RIVETS CSK IN .040 SKIN AT 1.10 IN SPACING.

STRENGTH $= 310/1.1$ $= \underline{282 \text{ LB/IN}}$

MAX LOADING $= \sqrt{154^2 + (.33 \times 154 \tan\alpha)^2}$ $= \underline{160 \text{ LB/IN}}$

MARGIN OF SAFETY $= \dfrac{282}{160 \times 1.25} - 1$ $\underline{\underline{MS = .41}}$

b) ATTACHMENT TO TRAILING EDGE CLOSURE

ATTACHMENT TO OUTBOARD TRAILING EDGE CLOSURE WITH 3/32 AD4 RIVETS IN .040 AT 1.0" SPACING

STRENGTH $\doteq \underline{217 \text{ LB/IN}}$

MARGIN OF SAFETY $= \dfrac{217}{160 \times 1.25} - 1$ $\underline{\underline{MS = .09}}$

c) ATTACHMENT TO RIBS.

ATTACHMENT WITH 1/8" AD4 RIVETS IN .040 SKIN. AT 1.25 INCH SPACING. STRENGTH/RIVET $= \underline{356 \text{ LB.}}$

THE END RIVET AT THE SPAR AND TRAILING EDGE

$= f_c A_{ve} = 3036 \times .04$ (PAGE 3.60.) $= \underline{121 \text{ LB}}$

MARGIN OF SAFETY $\underline{MS > 1.0}$

TRAILING EDGE SKIN PANELS

INNER PANELS (88.25 - 484.25)

INITIAL BUCKLING (SM 33)

PANEL SIZE $a = 29$, b 14.67, $t = .040$ $b/t = 367$

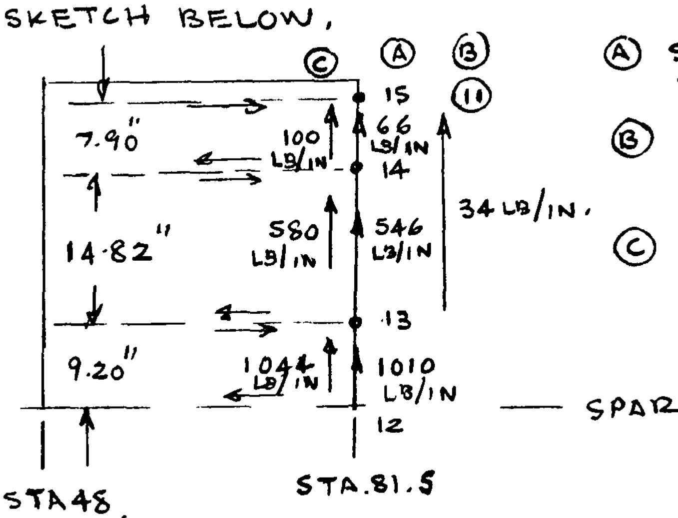
$b/a = .50$ $\sqrt{K} = 3.21$ $b/t_e = 367/3.21 = 114$

$F_{CR} = 750$ $q_b = 750 \times .04$ $= 30$ LB/IN

THE PANEL SHEARS ARE LESS THAN FOR THE OUTER PANELS ∴ MARGIN OF SAFETY MS > 1.0

ROOT END PANEL (48 - 88 25)

THIS PANEL IS USED TO SHEAR OUT THE AXIAL LOAD IN THE TRAILING EDGE STRUCTURE INTO THE LEADING EDGE BOX AND THE STATION 48 AND 81.5 RIBS. THE LOADS ARE MAXIMUM FOR CONDITION 3 ON THE UPPER SURFACE. LOADS ARE OBTAINED WITH REASONABLE ACCURACY FROM THE RIB REACTION LOADS AT STATION 81.5 REVISED AS DESCRIBED ON PAGES 3.14 & 3.15 AND THE LOADS OUTBD OF STATION 81.5 AS SHOWN IN THE SKETCH BELOW.



Ⓐ SHEAR FLOWS FROM PAGE 3.A.95 9 12 13 & 14

Ⓑ SHEAR FLOW FROM PAGE 3.A.42 & 81

Ⓒ RESULTANT SHEAR FLOW INBOARD OF STA 81.5.

TRAILING EDGE SKIN PANELS

ROOT END PANEL. CONT'D

IN ORDER TO PROVIDE A STIFF PATH FOR THIS LOAD TRANSFER THE PANEL IS MADE SHEAR RESISTANT BY ADDING STIFFENERS BETWEEN THE STA 59.58 & 71.16 RIBS. INTITIAL BUCKLING (SM 33)

PANEL SIZE $a = 33.0''$ $b = 5.80''$ $t = .08$

$$b/t = 72.5 \qquad b/a = .175 \qquad \sqrt{K} = 2.92$$

$$b/t_e = 72.5/2.92 = 25 \qquad F_{CR} = 16500 \text{ psi}$$

$$q_b = 16500 \times .08 \qquad = \underline{1320 \text{ lb/in}}$$

MAXIMUM q FOR COND. 3 $= \underline{1044 \text{ lb/in}}$

∴ THE PANELS DO NOT BUCKLE

ULTIMATE ALLOWABLE SHEAR FLOW FOR THE WEB ALLOWING A .75 FACTOR FOR AREA REMOVED BY ATTACHMENT HOLES $= 38000 \times .75 \times .08 \qquad = \underline{2280 \text{ lb/in}}$

MARGIN OF SAFETY $= \left(\dfrac{2280}{1044 \times 1.25}\right) - 1$ $\qquad$ MS = .75

ATTACHMENTS. (MIL HNDBK 5)

a) ATTACHMENT TO RIB & STA. 48 & 81.5

3/16" HILOKS AT 1.0 SPACING. CSK. IN .080 SKIN

STRENGTH (ULTIMATE) $= \underline{1630 \text{ LB/IN}}$

MARGIN OF SAFETY $\left(1630/1044 \times 1.25\right) - 1$ $\qquad$ MS. = .25 MS

b) ATTACHMENT TO SPAR CAP

3/16 HILOKS CSK IN 0.080 SKIN AT 1.0 SPACING

STRENGTH (ULTIMATE) $= \underline{1630 \text{ LB/IN}}$

MARGIN OF SAFETY $= \left(1630/1044 \times 1.25\right) - 1$ $\qquad$ MS = .25

TRAILING EDGE SKIN PANELS.

PANEL JOINTS.

THE PANELS ARE JOINED AT STATIONS 88.25, 220.25, 352.25, 484.25 & 661.25. THE SKINS ARE BUTTED TOGETHER AND JOINED WITH A .040 THICK 2024-T3 BUTT STRAP. 4 ROWS OF $\frac{1}{8}$" LS 10052 RIVETS AT 1.0 INCH SPACING ARE FASTENED EACH SIDE OF THE JOINT. THESE RIVETS ARE SIMILAR TO FLUSH HEAD AD 4 RIVETS BUT WITH A LOWER CSK. HEAD HEIGHT TO AVOID A FEATHER EDGE CONDITION

THE MAXIMUM JOINT LOADING OCCURS ON THE UPPER SURFACE FOR CASE 3 AT STA 220.25. PRELIMINARY ANALYSIS SHOWS THAT FOR THIS CONDITION USING THE UPPER .040 SKIN FULLY EFFECTIVE IN TENSION ($\bar{X} = -.83''$ $\bar{Z} = .02''$ $I_{xx} = 857$, $I_{zz} = 3050$ $I_{xz} = 47$ INS^4)

THE STRESS ALONG THE UPPER SKIN IS ESSENTIALLY

CONSTANT AT A VALUE		=	25000 PSI
LOADING/IN.	$= 25000 \times .04$	=	1000 LB/IN
PANEL SHEAR FLOW	$= 83 + 8$	=	91 LB/IN
RESULTANT LOADING	$= \sqrt{1000^2 + 91^2}$	=	1004 LB/IN

STRENGTH OF LS 10052 RIVETS AT 1.0" SPACING

4 ROWS	$= 4 \times 310$ (ULTIMATE)	=	1240 LB/IN
	$= 4 \times 267$ (YIELD)	=	1068 LB/IN

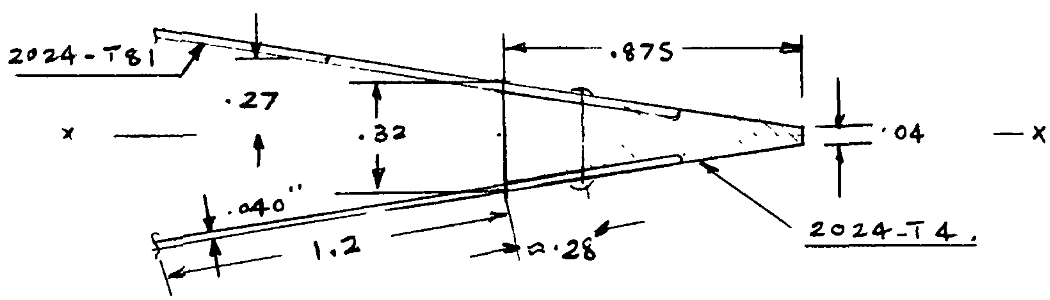
MARGIN OF SAFETY ON YIELD $= \frac{1068}{1004} - 1 = \underline{.06}$

FORM 3628-2

PREPARED BY A. CHERRITT	DATE 5/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.65
CHECKED		TITLE 100 KW WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

TRAILING EDGE CLOSURE. STA 565 – 750.

COLUMN ALLOWABLE.



$$A = \left(\frac{.32 + .04}{2}\right) .875 \;+\; 2 \times 1.2 \times .04 \qquad = \quad .253 \text{ INS}$$

157   096

$$I_{xx} = \frac{.875 \times .36\,(.04^2 + .32^2)}{48} + 2 \times .04 \times .27^2 \qquad = \quad .0065 \text{ INS}^4$$

$$\rho = \sqrt{\frac{.0065}{.253}} = .160$$

SPACING OF SUPPORTING RIBS = 14.67 INS.

$L/\rho = 14.67/.160 = 91.6.$ F_{cc} (COLUMN, SM 83) = 12000 psi

CHECK EFFECTIVE SKIN b_e (SM 23)

FOR $f_c = 12000$ $b_e/t_e = 29.3$ $c = 2.52$

b_e (ONE SIDE OF RIVET) $= \dfrac{29.3 \times 2.52 \times .04}{2} \quad = \quad 1.48$ INS.

b_e USED $1.20 + .28 = 1.48$ INS

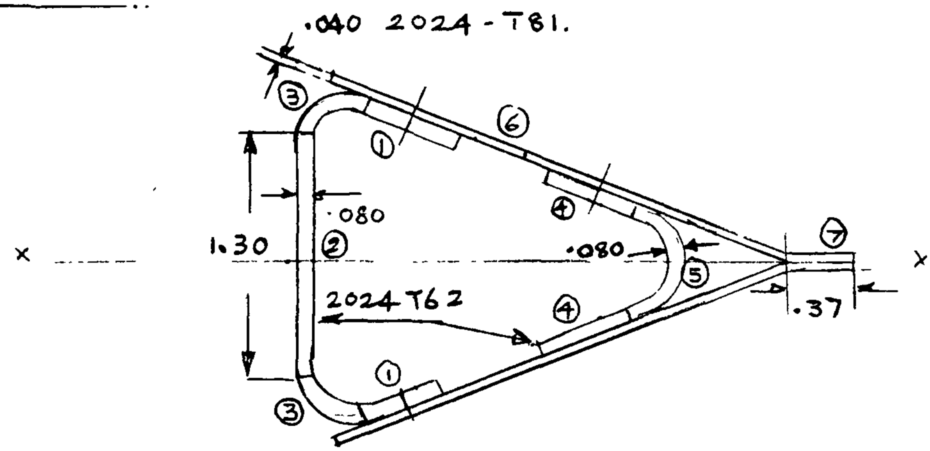
MAXIMUM COMPRESSIVE STRESS CASE 2 AT

STA 565 = 5900 + 1160 = 7060 psi

$$MS = \left(\frac{12000}{7060 \times 1.50}\right) - 1 \qquad MS. = .13$$

TRAILING EDGE CLOSURE STA. 187.5

COLUMN ALLOWABLE.



ITEM	A INS^2	Z IN	I INS^4	I_o
1	.080	.800	.051	–
2	.104	0	–	.015
3	.050	.820	.070	
4	.080	.330	.009	
5	.030	0	0	
6	.230	.530	.065	.019
7	.030	0	0	–
	.604		.195	.034

$I_{xx} = .229\ INS^4$

$\rho = \sqrt{\dfrac{.229}{.604}} = .616 IN$

$L = 14.67$ INS.

$L/\rho = 24$

$F_{cc} = 45000$ psi

(S.M. 83)

MAXIMUM COMPRESSIVE STRESS CASE 2

$= 17180 + 5330 \qquad = 22510$ psi

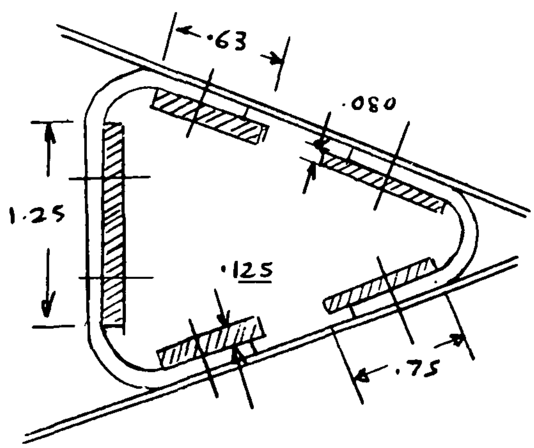
MARGIN OF SAFETY $= \left(\dfrac{45000}{22510 \times 1.50}\right) - 1 = .33$ MS.

FORM 362B-2

TRAILING EDGE CLOSURE JOINTS.

JOINT AT STA 187.5.

AT STATION 187.5 THE TRAILING EDGE CLOSURUE CHANNEL & ANGLE ARE BUTT JOINED WITH FLAT STRAPS AS SHOWN IN THE SKETCH BELOW



SPLICE STRAPS.
2024-T81

THE SPLICE STRAPS REPLACE THE AREA OF THE ANGLE & CHANNEL AND ARE EACH ATTACHED WITH 4 NAS1398DA4 RIVETS EACH SIDE OF THE JOINT.

MAXIMUM STRESS IS FOR CASE 2. $= -22510$ PSI

LOAD IN EACH .080 STRAP $= -22510 \times .75 \times .08 = -1350$ LB.

STRENGTH OF 4 RIVETS IN .080 $= 4 \times 755 = 3020$ LB.

MARGIN OF SAFETY $= \dfrac{3020}{1350 \times 1.5} - 1$ MS $= .49$

LOAD IN EACH OUTER .125 STRAP

$= -22510 \times .63 \times .125 = -1744$ LB.

ATTACHMENT STRENGTH $= 3020$ LB.

MARGIN OF SAFETY $= \dfrac{3020}{1744 \times 1.5} - 1 = .15$

TRAILING EDGE CLOSURE.

JOINT AT STA. 187.5

THE FLAT STRAPS ARE UNSUPPORTED FOR 1.0" BETWEEN ATTACHMENTS. COMPRESSIVE STRENGTH OF STRAP

$\rho = \sqrt{\frac{.08^2}{12}} = 023 \quad \ell/\rho \quad 43$

F_c SM 83. $= \underline{47000 psi}$

MARGIN OF SAFETY $= \frac{47000}{22510 \times 1.5} - 1$ $\underline{MS. = .39}$

JOINTS AT OTHER STATIONS 315 67 & 447.67 ARE JOINED WITH ANGLES IN PLACE OF FLAT STRAPS, THEY HAVE THE SAME Nº OF ATTACHMENTS & LOWER LOADS. THEY ARE, THEREFORE, COVERED BY THE ANALYSIS AT STA. 187.5.

ATTACHMENT OF TE. CLOSURES STA. 48 - 81.5.

THE LOADIN THE CLOSURES AT STATION 8175 MUST SHEAR OUT INTO THE SKIN BETWEEN STA. 81.5 & 48. THE MINIMUM MARGIN IS FOR CASE 2 FOR THE CHANNEL CLOSURE ATTACHMENTS.

MAX. STRESS (PAGE 3.29) = -17620 - 4870 $= \underline{-22490 psi}$

AREA OF CHANNEL & REINFORCING DOUBLERS IN THE GRID POINT AREA. $= \underline{.44 \text{ INS}^2}$

LOAD TO BE SHEARED OUT INTO SKIN. = .44 x 22490 = $\underline{9900 \text{ LB.}}$

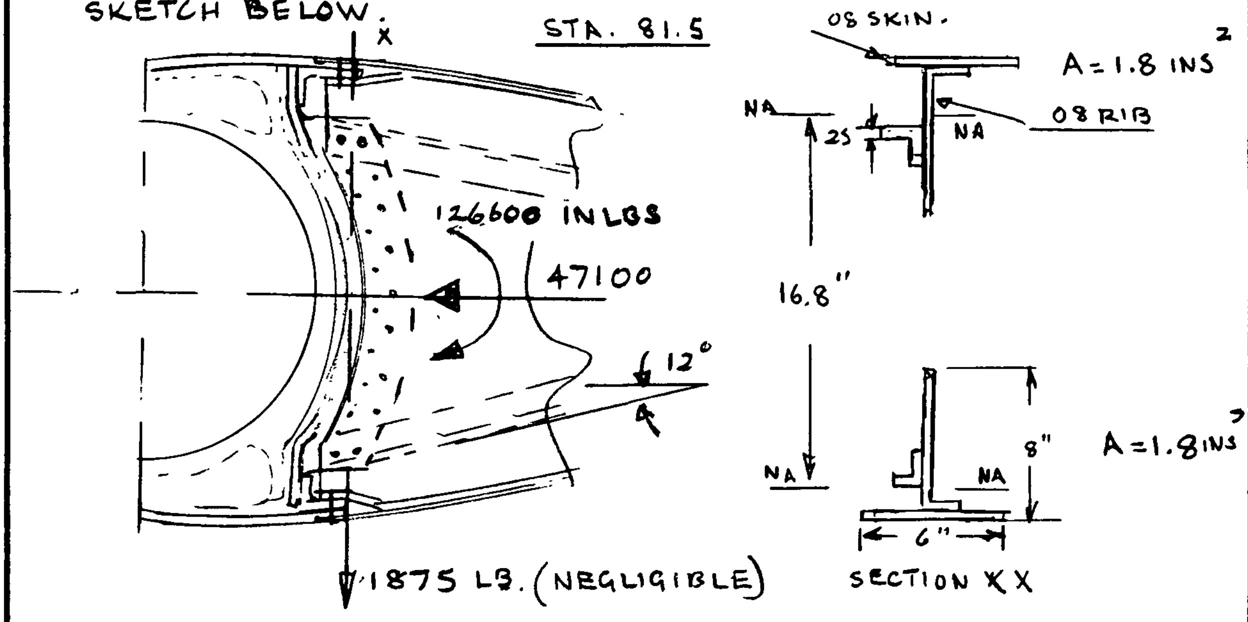
LOAD/IN = 9900/33 = $\underline{300 \text{ LB/IN.}}$

STRENGTH OF NAS 1398 D5A 5/32 RIVETS IN .080 AT .75 INCH SPACING = 755/.75 = $\underline{1006 \text{ LB/IN}}$

MS. $= \frac{1006}{300 \times 1.5} - 1$ $\underline{MS > 1.0}$

TRAILING EDGE RIBS STA 48 & 81.5

THE AXIAL LOAD IN THE TRAILING EDGE STRUCTURE WHICH SHEARS OUT BETWEEN STATIONS 81.5 & 48 PRODUCE CHORDWISE AXIAL LOADS IN THE TWO RIBS. THESE TWO TRAILING EDGE RIBS ARE .080 THICK AND ARE REINFORCED WITH TWO 1.5 X 1.5 X .025, 2024 T4 EXTRUSIONS ON EACH RIB, ATTACHED DIRECTLY TO THE HEAVY MACHINED LEADING EDGE RIBS WITH 2 3/8 HILOKS. THE HIGHEST LOADED RIB IS AT STATION 81.5 FOR CONDITION 3. LOADS ARE OBTAINED FROM THE RIB REACTION SHEAR FLOWS SHOWN ON PAGE 3.A.95 AND SUMMED UP TO THE ATTACHMENT FACE AS SHOWN IN THE SKETCH BELOW.



ASSUME THE EFFECTIVE AREAS AS SHOW ABOVE

MAXIMUM LOAD ON LOWER SURFACE

$$= \left[\frac{47100}{2} + \frac{126600}{16.8}\right] \frac{1}{\cos 12^\circ} = \underline{31100\ \text{LB.}}$$

COMPRESSIVE STRESS $= 31100/1.8 = \underline{17300\ \text{PSI}}$

TRAILING EDGE RIBS STA. 48-81.5.

F_{CY} OF 2024-T4 EXTRUSION = 38000 psi

MS ON YIELD (COLUMN NOT CRITICAL) MS > 1.0

ATTACHMENTS.

THE ATTACHMENTS ARE MADE WITH:-

2 x 3/8" HILOKS IN REINFORCING ANGLE

6 x 3/16 HILOKS IN .080 TRAILING EDGE SKIN

6 x 3/16 HILOKS IN .080 RIB WEB. (2024-T62)

TOTAL STRENGTH = 2x10490 + 6x1520x1.14 + 6x1630

= 41150 LB.

MARGIN OF SAFETY ON ATTACHMENT

$$= \frac{41150}{31100 \times 1.25} - 1 \qquad MS = .06$$

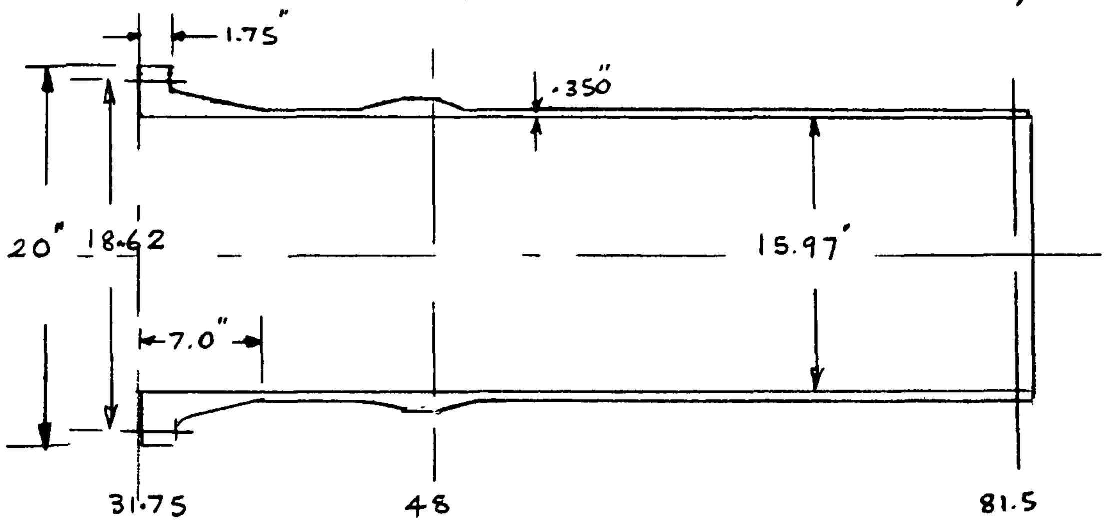
ROOT ATTACHMENT EXTENSION. (CL1708-1-15)

MATL. LOW ALLOY CARBON STEEL

F_{TU} 120000 PSI F_{TY} = 99000 PSI

F_{SU} 72000 PSI

(INTERPOLATED FROM MIL HDBK 5)



The root attachment extension fits inside the blade root between Station 48 and 81.5. The blade centrifugal force is taken by attachments to this fitting through the 81.5 rib and also along the curved spar web for a length of approximately ten inches. Blade bending and shear loads are transferred to the fitting by couple loads at the Station 48 and 81.5 ribs. The maximum bending-stresses occur at Station 38.75 and the maximum shear stresses occur between Station 48 and 81.5 where the fitting is subjected to the large couple shears. Local flange bending stresses are also calculated at the attachment flange Station 31.75.

ROOT ATTACHMENT EXTENSION.

SECTION PROPERTIES

O.D. = 16.67. ID = 15.97. $I = \pi/4 (8.335^4 - 7.985^4) = \underline{597.7 \text{ INS}^4}$

$A = \pi (8.335^2 - 7.985^2) = \underline{17.94 \text{ INS}^2}$

CENTRIFUGAL FORCE AT STA 31.75 = 24400 LB.

STRESS FROM CF $= \dfrac{24400}{17.94} = \underline{1360 \text{ PSI}}$

SUMMARY OF STRESSES AT STATION 38.75

(BENDING MOMENTS AT STA. 31.75 CONSERVATIVELY USED.)

CASE	BEAMWISE BENDING M_x	CHORDWISE BENDING M_z	RESULTANT BENDING M_R	BENDING STRESS f_b	C.F. STRESS f_T	TOTAL TENSILE STRESS
	IN.LBS.	IN. LBS	IN LBS.	PSI	PSI	PSI
1 MEAN	310000	35000	312000	4350	1360	5710
2 MEAN	62000	1660000	1661000	23160	1360	24520
4 MEAN	-675000	-390000	779600	10870	1360	12230
1,2&4. CYCLIC	±267000	±430000	± 506200	± 7060	—	± 7060
3 TOTAL	-2570000	-3140000	4058000	56590	1360	57950

(SHEAR STRESSES ARE LESS THAN 2500 PSI FOR CASE 3 AND ARE IGNORED.)

ROOT ATTACHMENT EXTENSION

SUMMARY OF STRESSES STA. 48 - STA 81.5.

a) SHEAR STRESS.

CASE	BEAMWISE SHEAR S_Z	CHORDWISE SHEAR S_X	RESULTANT SHEAR S_R	f_s * SHEAR	TORSION M_Y	f_s TORSION	f_s TOTAL
	LB	LB	LB	PSI	IN LB.	PSI	PSI
1 MEAN	11920	70	11920	1330	-6720	50	1380
2 MEAN	25060	-46100	52470	5850	-47500	330	6180
4 MEAN	-17680	9560	20100	2240	12950	90	2330
1,2 & 4 CYCLIC	∓ 6520	∓ 12780	± 14350	1600	± 4100	30	1630
3 TOTAL	-84620	69360	109400	12200	158900	1100	13300

$f_s = S_R/2A$.

b) AXIAL STRESS.

SINCE THERE IS LITTLE BENDING MOMENT CHANGE BETWEEN STATION 31.75 & 48, THE STRESSES TABULATED FOR STA. 38.75 ARE ASSUMED TO APPLY AT STA. 48 REDUCING LINEARLY TO ZERO AT STA. 81.5.

ATTACHMENT BOLT LOADS & FLANGE STRESS STA 31.75

TENSILE LOADS ARE TAKEN BY 24 5/8" BOLTS ON A 18.62" DIA. . SHEAR & TORSION LOADS ARE TAKEN BY 4 1/2 BOLTS IN CLOSE TOLERANCE HOLES.

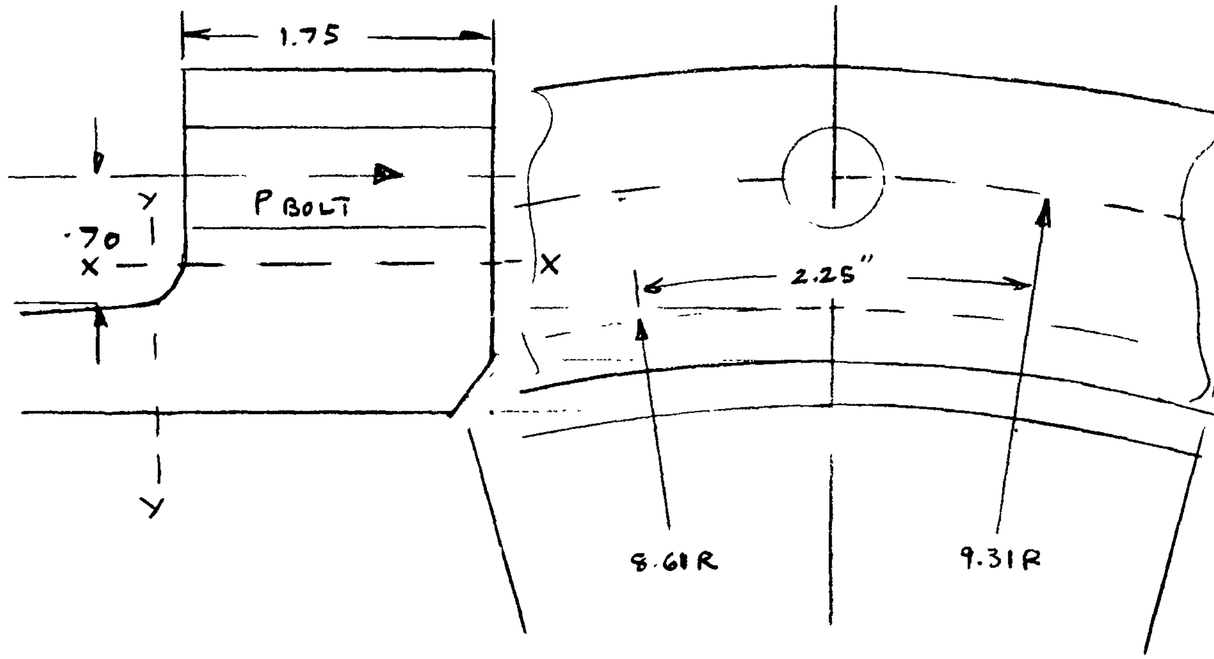
MAXIMUM TENSILE BOLT LOAD FROM BENDING

$= \frac{M}{12R}$ & FROM CENTRIFUGAL FORCE $= \frac{CF}{24}$

$CF = 24400$ LB $\qquad P_{CF} = 1020$ LB.

ROOT ATTACHMENT EXTENSION.

ATTACHMENT BOLT LOADS & FLANGE STRESS STA. 31.75



LOCAL FLANGE BENDING STRESS SECTION XX.

$$f_B \simeq \frac{.7\ P_{BOLT} \times 6}{1.75^2 \times 2.25} \text{ (CONSERVATIVELY USING .70" OFFSET)} = \underline{.61\ P_{BOLT}}.$$

BOLT LOADS & FLANGE STRESSES ARE TABULATED BELOW.

CASE	1 MEAN	2 MEAN	4 MEAN	1 2&4 CYCLIC	3 TOTAL.
RESULTANT M_R INLBS.	312000	1661000	779600	± 506200	4058000
P_{BOLT} BEND. LB	2790	14780	6980	± 4530	36320
P_{BOLT} CF LB	1020	1020	1020	0	1020
P_{BOLT} TOTAL LB.	3810	15890	8000	± 4530	37340*
FLANGE XX STRESS f_B.	2325	9690	4880	± 2765	22780

* SEE PAGE 3.75

ROOT ATTACHMENT EXTENSION

ATTACHMENT BOLT LOADS & FLANGE STRESS

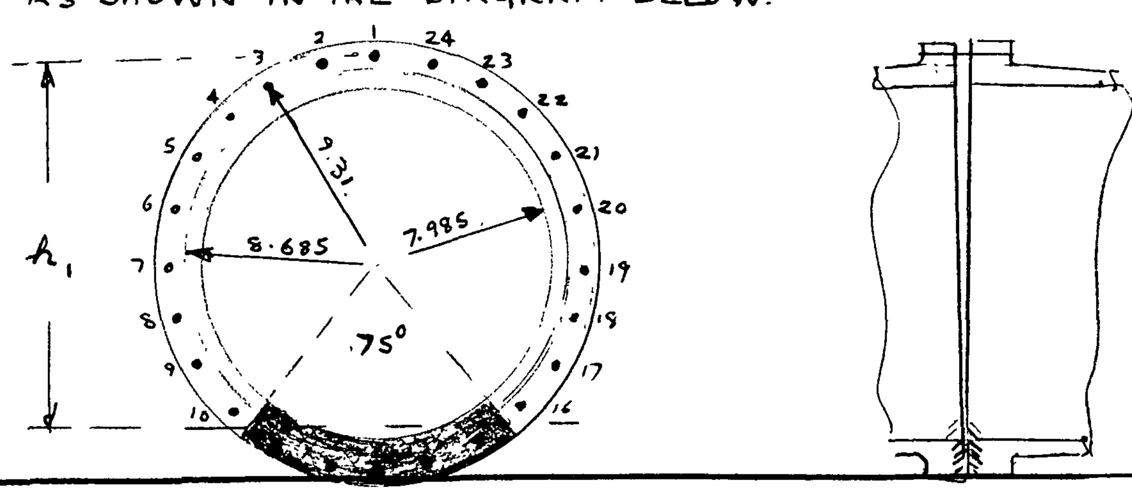
THE BOLT LOADS CALCULATED ON PAGE 3.74 ARE BASED UPON A NORMAL BENDING DISTRIBUTION $= Mc/I$ WHICH APPOXIMATES THE ACTUAL DISTRIBUTION PROVIDING THE PRELOAD ON THE ATTACHING BOLTS IS NOT EXCEEDED. THE BOLT PRELOAD SHOULD EXCEED THE MAXIMUMUM CACLULATED BOLT LOAD FOR THE MAXIMUM NORMAL OPERATING CONDITION IE CASE 2

BOLT LOAD = 15890 + 4530 = 20420 LB.

USING MIL-T-5544 LUBRICANT APPLIED TO THE THREADS AND TO THE BEARING SURFACES OF THE NUT & BOLT HEAD A TORQUE OF 1400 INCH LBS WILL PRODUCE A PRELOAD OF 28000 LB. IN THE 180 KSI 5/8" TENSION BOLTS RECOMMENDED FOR THIS ATTACHMENT.

CASE 3.

FOR THIS CONDITION THE BOLT LOAD EXCEEDS THE PRELOAD AND THE MATING FLANGES WILL SEPARATE THE BENDING DISTRIBUTION IS ASSUMED TO BE AS SHOWN IN THE DIAGRAM BELOW.



ROOT ATTACHMENT EXTENSION

ATTACHMENT BOLT LOADS & FLANGE STRESS

CASE 3.

BOLT LOADS FOR THE DISTRIBUTION SHOWN ON PAGE 3.75 ARE GIVEN BY $P_{BOLT} = \dfrac{M h}{\sum h^2} + 1020$ (FROM C.F.)

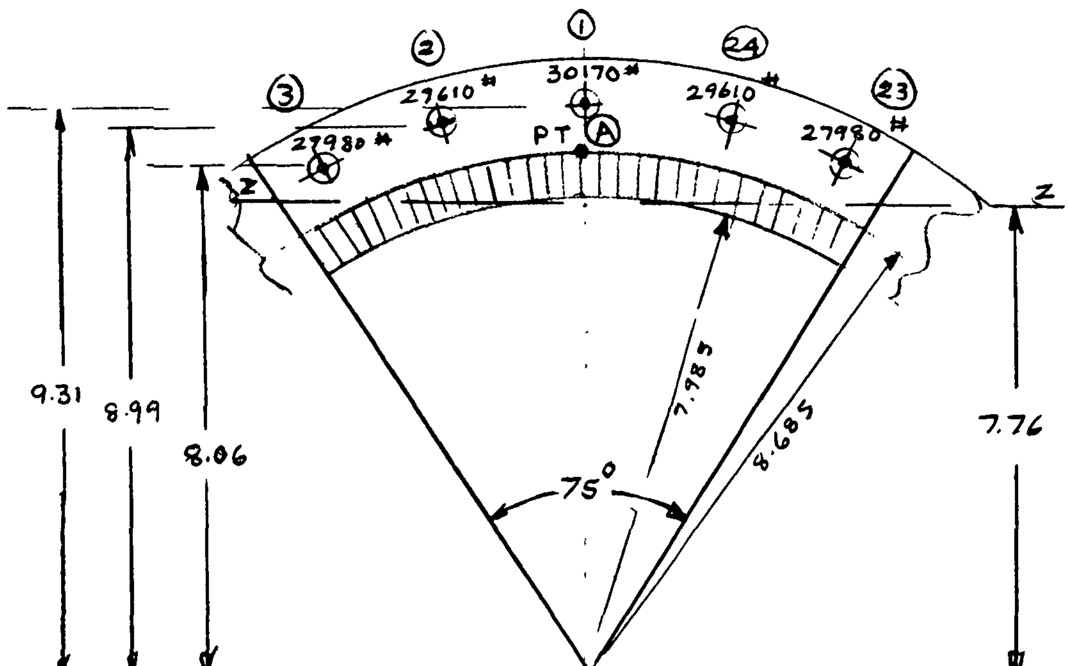
$M = 4058000$ IN.LBS & $\sum h^2 = 1157.6$ INS^2

HIGHEST BOLT LOAD ON BOLT Nº 1 = 30170 LB.

TENSILE STRENGTH OF A 5/8" 180 KSI BOLT = 43800 LB

MARGIN OF SAFETY $= \dfrac{43800}{30170 \times 1.25} - 1$ MS = .16.

THE HIGHEST STRESS IN THE FLANGE AREA Y-Y SHOWN ON THE SKETCH PAGE 3.74. ESTIMATION OF THIS STRESS WILL BE SIMPLIFIED CONSIDERING THE LOAD ON THE OUTERMOST 5 BOLTS PRODUCING AXIAL & BENDING STRESS ON A CIRCULAR SECTOR AS SHOWN BELOW



ROOT ATTACHMENT EXTENSION

ATTACHMENT BOLT LOADS & FLANGE STRESS

REFER TO THE SKETCH ON PAGE 3.76

I OF SHADED SECTOR. $= 2.31 \text{ INS}^4$

AREA OF SECTOR $= 7.64 \text{ IN}^2$

TENSILE LOAD FROM BOLTS 1, 2, 3, 23 & 24

$= 2 \times 27980 + 2 \times 29610 + 30170 \quad = 145350 \text{ LB}$

BENDING MOMENT FROM BOLT LOADS

$= 2 \times 27980 \times .30 + 2 \times 29610 \times 1.23 + 30170 \times 1.55 \quad = 136400 \text{ INLB}$

* MAX. STRESS AT POINT A $= \dfrac{145350}{7.64} + \dfrac{136400 \times .925}{2.31}$

$= 73650 \text{ PSI}$

MARGIN OF SAFETY ON YIELD

$MS = 90000/73650 - 1 \qquad MS = .22$

* SECONDARY "RING" STRESSES HAVE NOT BEEN INCLUDED SINCE THEY ARE NOT HIGH FOR A PIPE FLANGE WHICH IS PRIMARILY IN BENDING & ALSO NORMAL TO THE ABOVE STRESS AT POINT A (P 3.76)

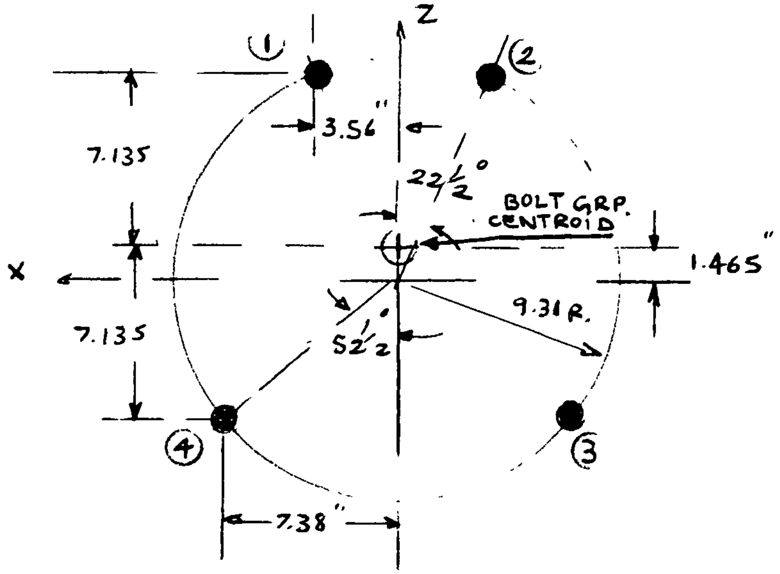
THE MAXIMUM FLANGE STRESS AT POINT A IS CALCULATED FOR THE OTHER DESIGN CASES AN IS TABULATED BELOW.

CASE	1	2	3	4
STRESS PSI. AT POINT A	6850 ± 8060	28250 ± 8060	73650	14300 ± 8060

PREPARED BY A. CHERRITT	DATE 4/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.78
CHECKED		TITLE 100 K.W. WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

ROOT ATTACHMENT EXTENSION

LOADS ON SHEAR ATTACHMENT BOLTS. STA 31.75



THE LOCATION OF THE FOUR SHEAR BOLTS IS SHOWN ON THE SKETCH ABOVE

THE MOMENT ABOUT THE BOLT GROUP CENTROID $M_T = M_y + 1.465\,S_x$

'X' LOAD IN BOLTS (1) (2) (3) & (4)

$$= S_x/4 \pm \frac{M_T \times 7.135}{\underbrace{(4\times 7.135^2 + 2\times 7.38^2 + 2\times 3.56^2)}_{338}} = S_x/4 \pm .02112\,M_T$$

'Z' LOAD IN BOLTS (1) & (2)

$$= S_z/4 \pm \frac{M_T \times 3.56}{338} = S_z/4 \pm .01054\,M_T$$

'Z' LOAD IN BOLTS (3) & (4)

$$= S_z/4 \pm \frac{M_T \times 7.38}{338} = S_z/4 \pm .0218\,M_T$$

THE SHEAR LOADS ARE RELATIVELY SMALL AND WITH A RECOMMENDED PRELOAD OF APPROXIMATELY 28000 LB ON THE 24 5/8" TENSION BOLTS SHEARS FOR OPERATING CONDITIONS WILL BE TAKEN THROUGH FRICTION OF

FORM 362B-2

ROOT ATTACHMENT EXTENSION.

LOADS ON SHEAR ATTACHMENT BOLTS STA. 31.75.

THE MATING SURFACES IGNORING FRICTION, HOWEVER, THE BOLT LOADS FOR THE HIGHEST LOADED BOLTS FOR EACH DESIGN CONDITION ARE SHOWN BELOW.

ITEM \ COND.	1 MEAN	2 MEAN	3 TOTAL	4 MEAN	1 2 & 4 CYCLIC
S_Z LB	2880	6410	-480	30	∓10
S_X LB	160	-2640	-10090	-300	∓1800
M_Y INLB	-330	-38500	154900	3240	±4330
M_T INLB	-100	-42370	140200	2800	±6970
BOLT No	3	3	2	1	3
P_X LB	38	-1554	-5483	-134	±597
P_Z LB	722	2526	-1598	68	±155
$P_{RES.}$ LB	723	2966	-5710	150	±617

SHEAR STRENGTH OF A 160 KSI ½" BOLT = 18650 LB.
(MIL-HNDBK 5B).

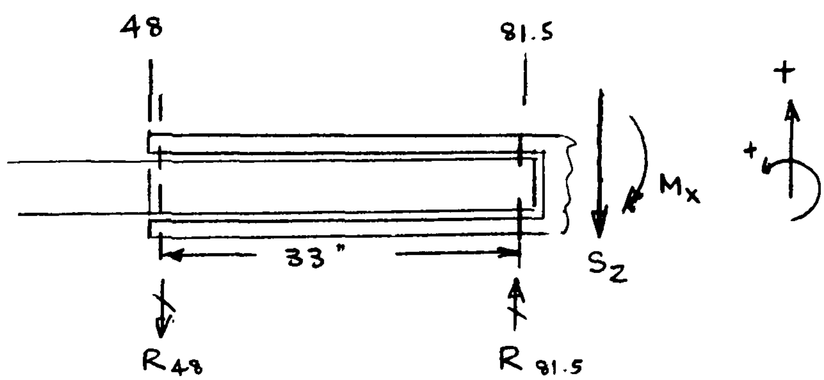
MARGIN OF SAFETY MS > 1.0.

ROOT ATTACHMENT EXTENSION & BLADE ROOT RIBS

AT THE STATION 48 & 81.5 RIBS THE BLADE BENDING MOMENTS ARE TRANSFERRED TO THE ROOT ATTACHMENT EXTENSION BY COUPLE LOADS ≈ $M/33$ AT EACH RIB. THESE LOADS RESULT IN RADIAL STRESSES IN THE RIBS AND THE ROOT ATTACHMENT EXTENSION. AT STATION 48 WHERE THERE IS NO MECHANICAL CONNECTION, THE LOAD IS TRANSFERRED BY THE RIB BEARING UPON THE ROOT EXTENSION. THE PARTS MUTUALLY SUPPORT EACH OTHER FROM DISTORTION BUT BEND INDIVIDUALLY. AT STATION 81.5 THE BLADE RIB AND THE ROOT ATTACHMENT EXTENSION ARE ATTACHED TOGETHER WITH 24, 7/16" BOLTS WHICH ALLOW THE PARTS TO ACT IN UNISON TO RESIST RADIAL LOADING. AT THIS LOCATION THE COUPLE LOAD CAN BE TRANSFERRED BOTH BY BEARING AND BY THE ATTACHMENT BOLTS.

STATION 81.5 RIB.

MAXIMUM DESIGN CONDITION CASE 3.
THE COUPLE LOADS AT STATION 81.5 ARE CALCULATED AS SHOWN IN THE LINE DIAGRAM BELOW



ROOT ATTACHMENT EXTENSION & BLADE ROOT RIBS

STATION 81.5 RIB.

S_Z (MEAN + CYCLIC) $= -7010 - 1750 = \underline{-8760\ LB}$

M_X (MEAN + CYCLIC) $= -2114700 - 388700 = \underline{-2503400\ IN\ LB}$

$R_{Z\ 81.5} = 8760 + \dfrac{2503400}{33} = \underline{+84620\ LB}$.

IN A SIMILAR MANNER FOR CHORDWISE LOADING

S_X (MEAN + CYCLIC) $= +3995 + 780 = \underline{+4775\ LB}$

M_Z (MEAN + CYCLIC) $= -2376600 - 193800 = \underline{-2570400\ IN LB}$

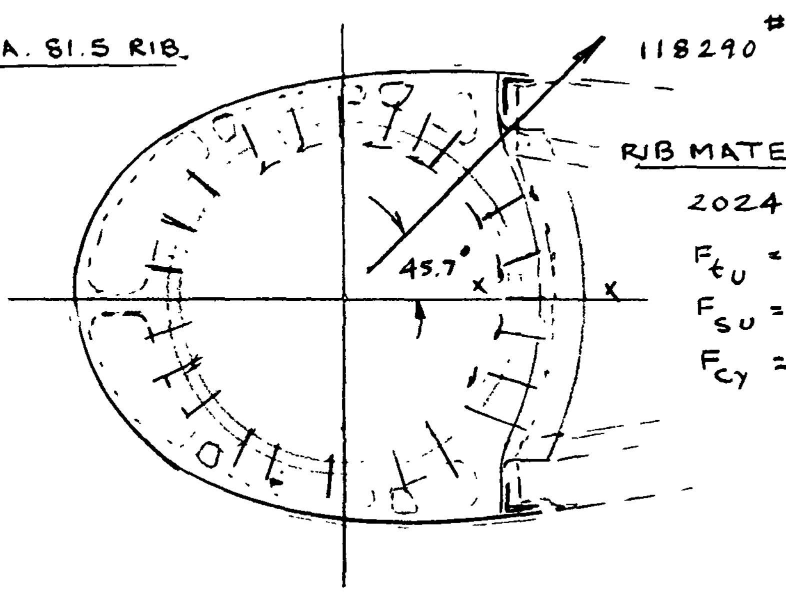
$R_{X\ 81.5} = -4775 - \dfrac{2570400}{33} = \underline{-82660\ LB}$.

RESULTANT REACTION $= \sqrt{84620^2 + 82660^2} = \underline{118290\ LB}$.

ANGLE OF RESULTANT FROM X REFERENCE AXIS

AT STATION 81.5 $= \tan^{-1} \dfrac{84620}{82660} = \underline{45.7°}$

STA. 81.5 RIB.



RIB MATERIAL

2024 - T851

$F_{tu} = 66$ KSI

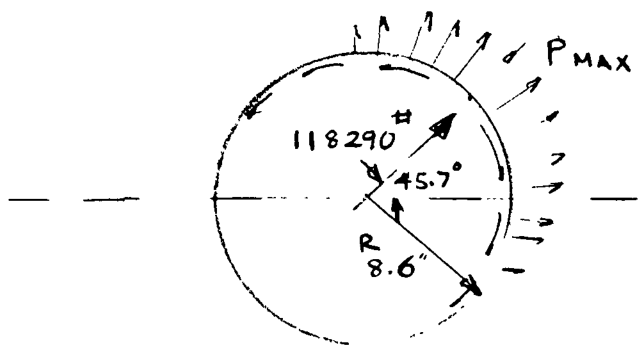
$F_{su} = 37$ KSI

$F_{cy} = 58$ KSI.

ROOT ATTACHMENT EXTENSION & BLADE ROOT RIBS.

STATION 81.5 RIB.

ASSUME ALL THE RESULTANT LOAD TAKEN BY BEARING ON THE 'RING' FORMED BY THE RIB & ROOT EXTENSION WITH A SINUSOIDAL LOADING AS SHOWN BELOW



$$P_{MAX} = \frac{2 \times 118290}{\pi \times 8.61} = \underline{8750\ LB/IN}$$

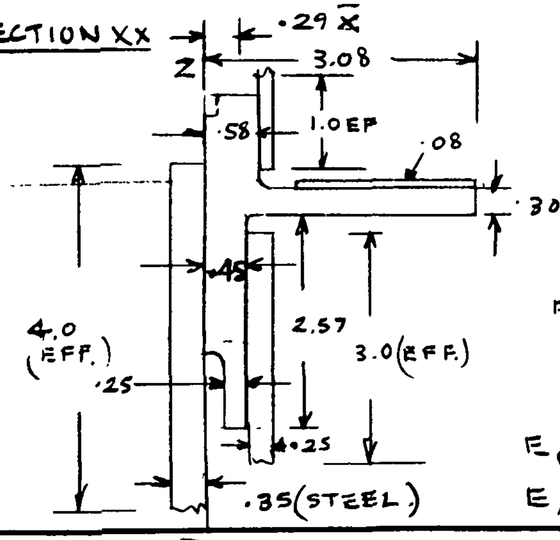
THE MAXIMUM LOADING OCCURS AT THE ℄ OF THE LOADING DISTRIBUTION

BENDING MOMENT $= .06832 \times 8750 \times 8.6^2$ $= \underline{44200\ IN\ LBS.}$

RADIAL LOAD N $= .75 \times 8750 \times 8.6$ $= \underline{56440\ LB.}$

THESE LOADS WILL BE CONSERVATIVELY BE APPLIED TO THE MINIMUM SECTION AT XX IN THE SKETCH. PG 3.81

SECTION XX



$A_{EFF.} = \underline{7.11\ INS^2}$

$I_{EFF.} = \underline{3.66\ INS^4}$

$\bar{X} = \underline{.290\ INS}$

EFFECTIVE STEEL AREA

$$E_S/E_{AL} \times A_S = 2.76\ A_S$$

$E_S = 29 \times 10^6$

$E_{AL} = 10.5 \times 10^6$

ROOT ATTACHMENT EXTENSION & BLADE ROOT RIBS.

STATION 81.5 RIB.

THE HIGHEST STRESS IS ON THE OUTSTANDING LEG OF THE RIB.

$$f_t = \frac{56440}{7.11} + \frac{44200 \times 2.79}{3.66} = \underline{41630 \text{ psi}}$$

MARGIN OF SAFETY ON YIELD.

$$= \frac{58000}{41630} - 1 \qquad \underline{\underline{MS. = .39}}$$

ATTACHMENTS.

FOR THE ATTACHMENTS IT WILL BE ASSUMED THAT ALL OF THE RESULTANT LOAD IS TAKEN BY THE 7/16" 160 KSI BOLTS ATTACHING THE RIB TO THE ROOT ATTACHMENT EXTENSION.

ASSUME 12 BOLTS TAKE THE LOAD

LOAD/BOLT (SHEAR) $= \frac{118290}{12} = 9860$ LB.

LOAD/BOLT FROM CENTRIFUGAL FORCE

$$23300/24 = 970 \text{ LB.}$$

RESULTANT SHEAR LOAD $= \sqrt{9860^2 + 970^2} = \underline{9910 \text{ LB/BOLT}}$

SHEAR STRENGTH OF BOLT (ULTIMATE) $= \underline{14280 \text{ LB.}}$

$$MS = \left(\frac{14280}{9910 \times 1.25}\right) - 1 \qquad \underline{\underline{MS = .15.}}$$

ROOT ATTACHMENT EXTENSION & BLADE ROOT RIBS.

STATION 48 RIB.

REACTION AT STATION 48 ARE CALCULATED FROM PAGE 3.81 AND ROTATED 5.44° TO BE RELATIVE TO THE REFERENCE AXIS AT STATION 48.

$R_z = -2503400/33 = -75860$ LB.

$R_x = +2570400/33 = +77890$ LB.

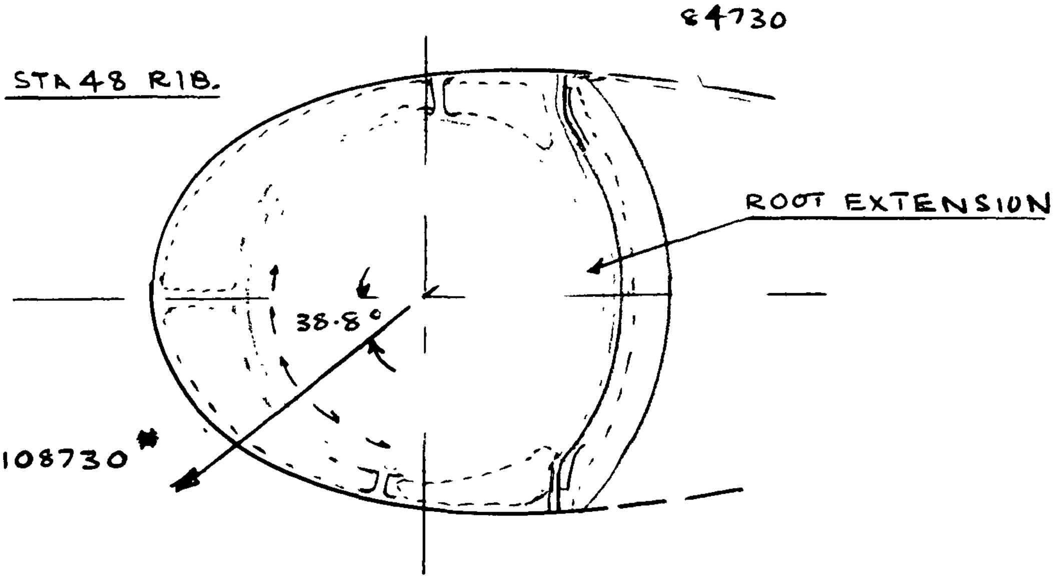
$R_{z_{48}} = -75860 \cos 5.44° + 77890 \sin 5.44° = \underline{-68140}$ LB

$R_{x\,48} = +75860 \sin 5.44° + 77890 \cos 5.44° = \underline{+84730 \text{ LB}}$

RESULTANT REACTION $= \sqrt{68140^2 + 84730^2} = \underline{108730 \text{ LB}}$

ANGLE OF RESULTANT LOAD $= \tan^{-1} \dfrac{68140}{84730} = \underline{38.8°}$

STA 48 RIB.



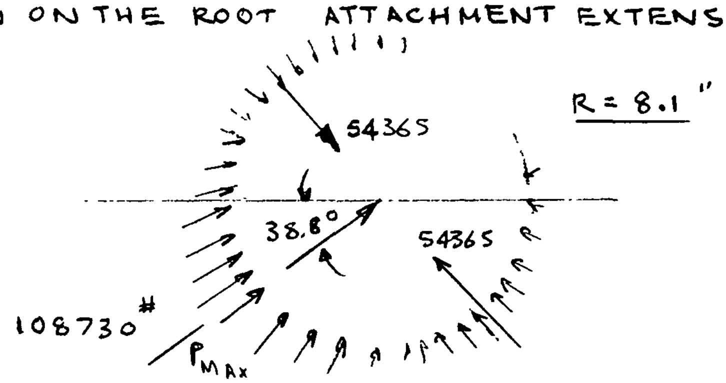
AT THIS STATION THE ROOT EXTENSION IS THE HIGHEST LOADED. THE LOAD MUST BE TAKEN OUT BY BEARING SINCE THERE ARE NO ATTACHMENTS AT THIS STATION. A SINUSOIDAL BEARING DISTRIBUTION IS

PREPARED BY a. Schmitt	DATE 6/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.85
CHECKED		TITLE 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

ROOT ATTACHMENT EXTENSION & BLADE ROOT RIBS

STATION 48 RIB./ATTACHMENT EXTENSION

ASSUMED THE RIB IS ASSUMED TO SUPPORT THE SIDES OF THE PIPE TO PREVENT DISTORTION AS SHOWN IN THE DIAGRAM BELOW. LOADS ARE SHOWN AS ACTION ON THE ROOT ATTACHMENT EXTENSION.



PRELIMINARY ANALYSIS SHOWS THE SUPPORT LOADS EQUAL 50% OF THE APPLIED LOAD

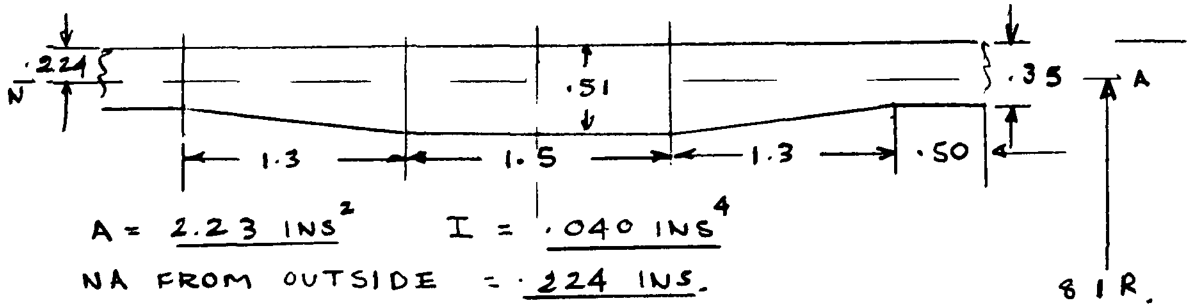
$$p_{MAX} = \frac{2 \times 108730}{\pi \times 8.1} = 8545 \text{ LB/IN}$$

LOADINGS ARE HIGHEST AT ℄ OF APPLIED LOADING

$$M = -.00606 \times 8545 \times 8.1^2 = -3400 \text{ INLB}$$

$$N = -1.143 \times 8545 \times 8.1 = -79110 \text{ LB.}$$

SECTION THROUGH ROOT EXTENSION AT STA 48.



$A = 2.23 \text{ INS}^2$ $I = .040 \text{ INS}^4$

NA FROM OUTSIDE = .224 INS.

FORM 362B-2

ROOT ATTACHMENT EXTENSION & BLADE ROOT RIBS.

STATION 48 RIB/ATTACHMENT EXTENSION.

MAXIMUM STRESS OCCURS IN THE ROOT EXTENSION PIPE COMPRESSION ON THE INNER FACE.

$$f_c = \frac{79110}{2.23} + \frac{3400 \times .266}{.040} = 58000\,psi$$

F_{ty} FOR STEEL EXTENSION = 99000 psi

MS ON YIELD $= \left(\frac{99000}{58000}\right) - 1$ MS = .71.

FATIGUE ALLOWABLES

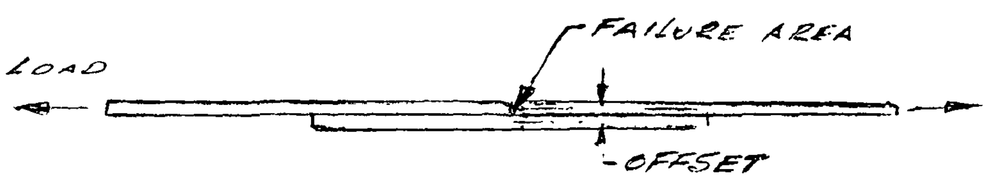
The high stress concentration areas in the blade occur in the joint areas.

Stress allowables in terms of cycles to failure are developed for the following types of structure:

1. Thin aft skin single butt joint.
2. Main box section containing flush attachment holes.
3. Trailing edge section containing flush attachment holes.
4. Steel root end flanged fitting.

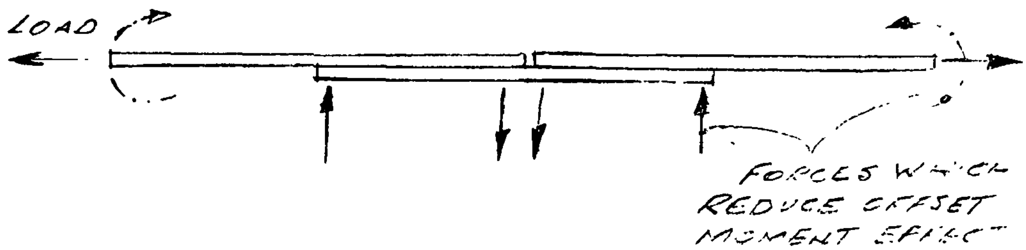
To allow for score marks and other realistic stress concentrations which can exist in a structure, a quality index of no less than five will be assumed for the general aluminum structure. The effective stress concentration factor K_T, for this index, will be assumed equal to 5 A $K_T = 4$ will be assumed for the 120,000 HT steel root fitting. The above will cover all areas other than the aft skin butt joint.

The fatigue allowables for the single butt joint are shown in Figure 2.2. In using this curve, it is necessary to consider several factors. The test specimens were flat without any fixation at the sides. The failure generally occurred in the center of the joint plate because of the offset bending induced in the plate, as shown below.



In the installed structure there is often the capability to reduce this

moment as shown below:



The relieving forces can be provided by hoop compression and tension if the panel is curved or by torsion/differential stiffness of the joint plate. The latter will depend on the proximity of stiffer local structure, such as ribs, stringers, spars, trailing edge members, etc. The net effect of these restraints would be to reduce the fatigue stress in the joint plate. This reduction would be dependent on the relative stiffness of the load paths.

The aft skin of the windmill blade does have slight curvature. The butt joint plate is wide using several rows of rivets and there is a stiffer local structure within reasonable proximity. It would not be unreasonable to have atleast a 20% reduction in bending fatigue stress due to these effects. Because of this expected reduction, the 10^7 cycles gross area stress of Figure 3.2 will be used as the endurance limit without applying a reduction factor.

Several design changes could improve the fatigue allowable of the joint. Among these would be the addition of an external plate which would result in a symmetrical joint and/or a chordwise stiffener below the joint.

FATIGUE LIFE

The life requirements for the blade are given below:

OPERATING MODES

Case No.	Blade Setting $\frac{r}{R_t} = .75$	Rotor Speed (RPM)	Wind Velocity (MPH)	Life Requirements (Hrs or Cycles)
1	0°	40	18	50,000 hrs
2	0°	40	60	10 gusts 25 cycles per gust
3	-90°	40	18	1 cycle
4	0°	40	0	-

The loads can be divided into categories as follows:

1. Steady loads which come on and off, similar to an aircraft ground, air ground cycle (stop, start).
2. High transient inputs which raise the steady loads, and induce higher cyclic loads which occur at a frequency greater than one per rev of the windmill (40 cycles per min.).
3. Normal operation cyclic loads greater than one per rev of the windmill.
4. Chordwise bending due to the weight of the blade which reverses at one per rev.

For categories 3 and 4, a simple analyses shows that at 40 RPM, 10^7 cycles would be reached in 4200 hours. The stresses arising from these loads must therefore be compared with the endurance limit.

For category 1 it is necessary to establish the number of times the steady loads reduce to a low level and when they get to operating levels. For this category it will be assumed that the loads go from near zero to normal 20 times per day for 10 years. This gives an order of 76,000 cycles. For the fatigue analysis, it will be assumed 100,000 cycles are achieved over the life of the blade.

For category 2 operating mode 2 would give a minimum of 250 cycles above one per rev. There will be other intermediate gust occurences. A minimum of 1000 cycles will be assumed at the cyclic levels for this mode in order to cover these intermediate conditions.

The beamwise and chordwise cyclic loads for the operational modes 1 and 2 are given in the loads section, Figure 2-10.

The steady loads for condition 1 and condition 2 are given in Figure 2-6 and Figure 2-7, respectively.

The cyclic loads for case 1 and 2 are shown to be the same. Under the ground rules established, these cyclic loads therefore must be below the endurance limit allowable.

Case 2, beamwise steady, is below that of case 1, hence, the steady loads due to beamwise to be associated with the cyclic loads will be taken as those for case 1. The steady and cyclic stresses for the design cases given are shown in Appendix A. The critical items covered are the blade upper and lower surface, spar cap, trailing edge, and the steel root fitting. From this data the stations giving the maximum total stress steady plus cyclic and the stations giving the maximum cyclic stress for each case are selected for analysis. These are listed below:

<u>Blade Upper Surface Stresses - psi</u>

Station	Design Case 1	2	3	4
81.5	- 810 ±1720	-4640 ±1000	19910	+5150 ±1000
235			23760	
653	-5070 ± 30	-9490 ± 30		

Blade Lower Surface Stresses - psi

Station	Design Cases 1	2	3	4
81.5	+ 3000 ∓ 1300			- 2890 ∓ 1300
235			- 19470	
653	+ 5700 ± 110	+ 10730 ± 110		

Lower and Upper Spar Cap Stresses

Station	Design Cases 1	2	3	4
81.5	+ 3050 ± 2110			+ 5750 ± 210
187.5		+ 2580 ± 1760	+ 28270	
81.5				- 2160 ± 2110
653	+ 6400 ± 50	+ 11810 ± 50		

Trailing Edge Stress

	Design Cases			
Station	1	2	3	4
187.5	760 ± 3040	- 17200 ± 5330	18600	3570 ± 3040

Steel Root Fitting at Flange Radius

Case	1	2	3	4
	6850 ± 8060	2830 ± 8060	73650	14300 ± 8060

The basic fatigue conditions are case 1, 2, and 4. Case 3 need only satisfy limit conditions.

The allowable aluminum endurance stress versus stress concentration is shown in Figure 3.3. Applying a 20% reduction to the endurance limit for $K_T = 5$ gives 4400 psi allowable. The cyclic stress in the aluminum structure for the high cycle conditions are below this value. The maximum compressive stress steady + cyclic is in the trailing edge structure at station 187.5 for case 2 (-17200 ∓ 5330). If this stress is considered as a maximum for the transient conditions (1000 cycles), the equivalent applies stress would be -11260 ± 11260 psi. The allowable cyclic stress for 1000 cycles ignoring the favorable effect of a compressive mean and taking zero mean is 19000 psi with a 20% reduction factor applied to the allowable shown in Figure 3.4.

The maximum tensile stress in the aluminum structure for case 1 is in the lower cap at station 653 (6400 ± 50). This condition for the 100,000 cycle stop/start is equivalent to a steady stress of 3225 psi with a cyclic stress

of 3225 psi. The allowable stress at this mean for 100,000 cycles is 6400 psi, with a 20% reduction factor applied to Figure 3.2.

The normal operating stress in the aluminum aft section skin joints to be compared with the endurance limit occurs at station 187.5 for case 1. The cyclic stress of ± 3040 psi for this case is equal to the allowable shown in Figure 3.2. This would indicate the joints to be one of the most critical fatigue areas. The 1000 cycle transient and 100,000 stop/start cycles cause relatively low fatigue damage when compared to the cyclic stress caused essentially by the basic weight of the blade during rotation.

The maximum cyclic stress of 8060 psi in the steel root fitting flange for all the fatigue condition is below the 9500 psi allowable shown in Figure 3.1 at the 6850 psi mean for condition 1.

The preceeding analysis indicates that the fatigue stress levels developed are compatible with the design objective providing that the load severity experienced in operation lies within the design conditions in Table I of Specification No. 3-572243.

L YOUNG
31MY72

S-N DIAGRAM
4130 NORMALIZED STEEL
$F_{TU} = 125$ KSI
$K_T = 4$

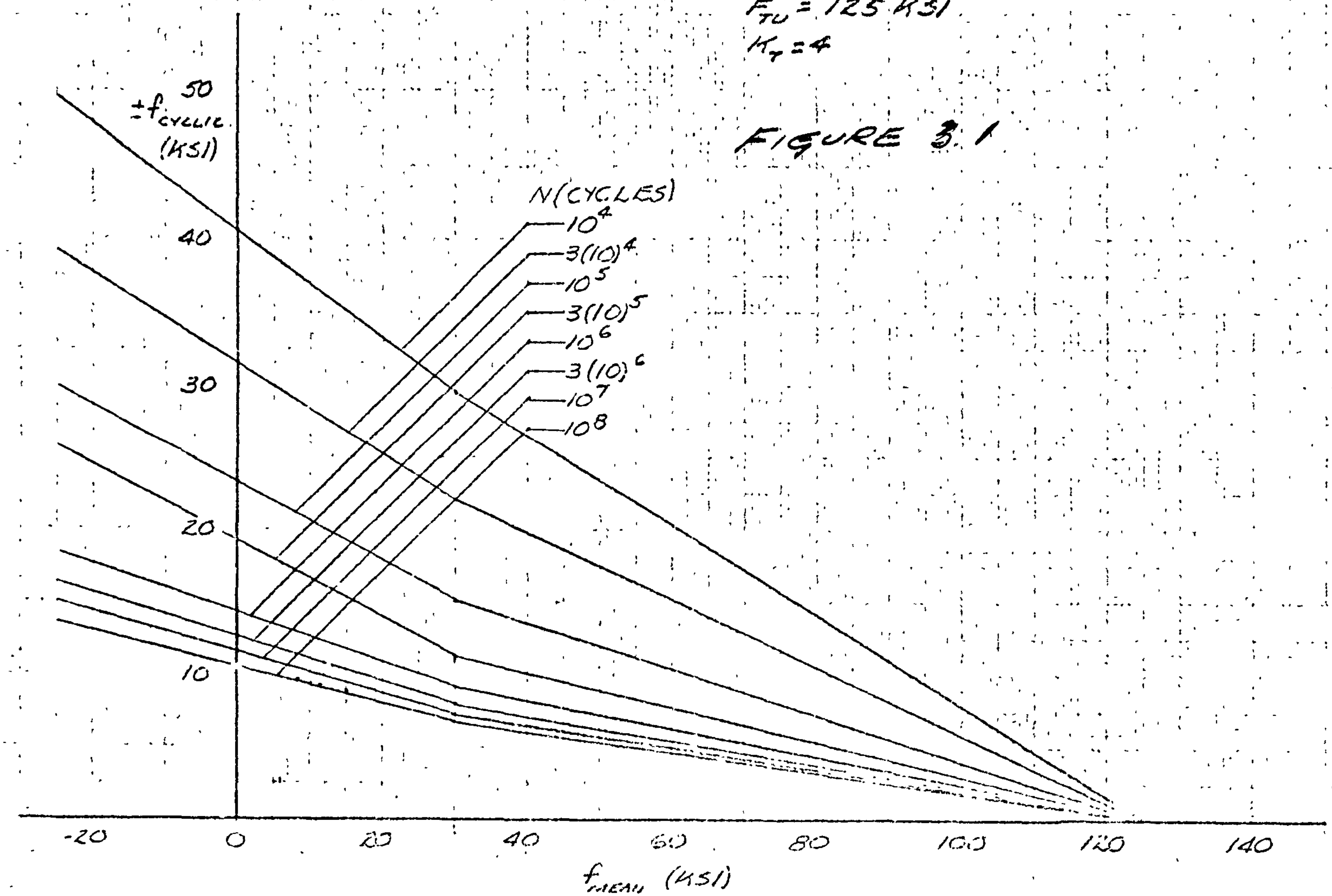


FIGURE 3.1

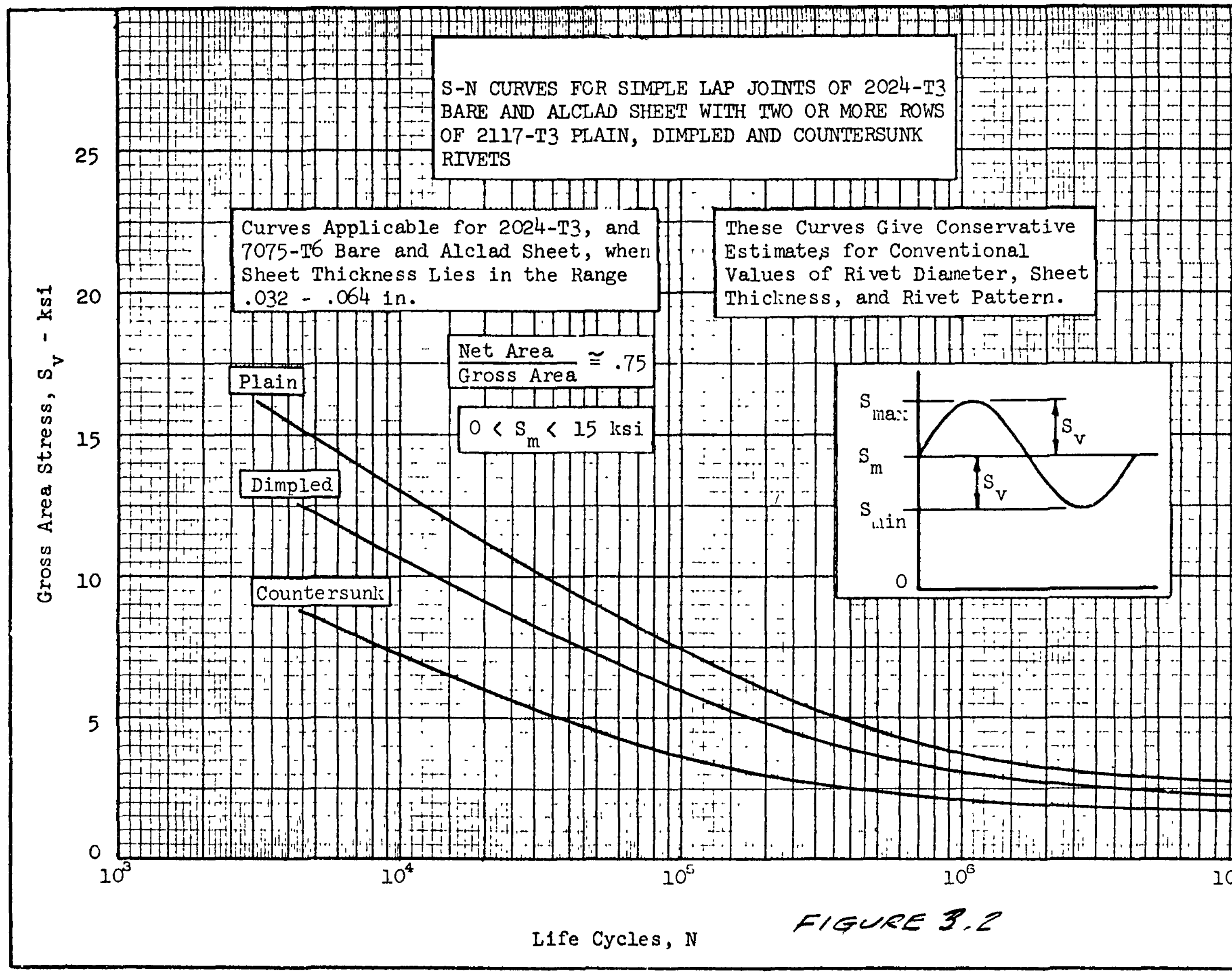
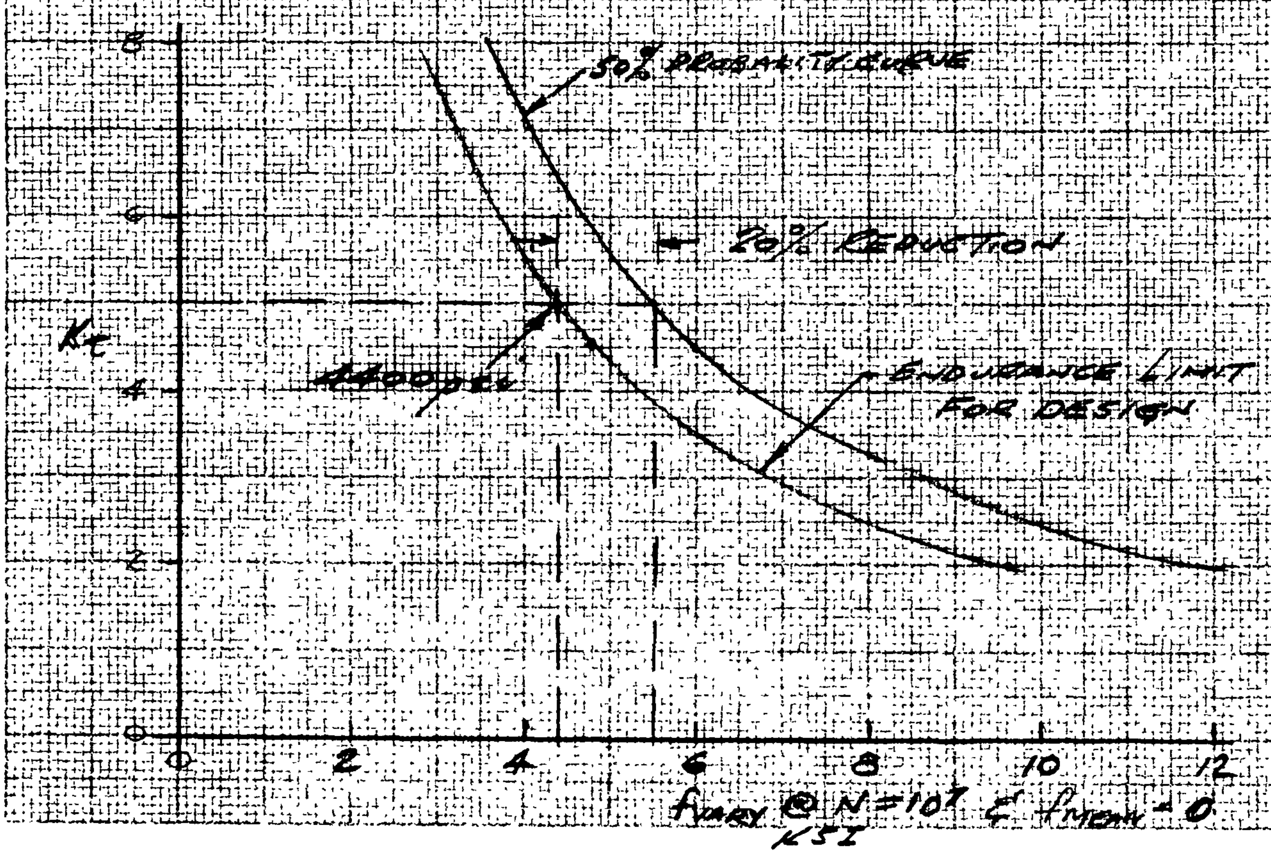

S-N CURVES FOR SIMPLE LAP JOINTS OF 2024-T3 BARE AND ALCLAD SHEET WITH TWO OR MORE ROWS OF 2117-T3 PLAIN, DIMPLED AND COUNTERSUNK RIVETS
Curves Applicable for 2024-T3, and 7075-T6 Bare and Alclad Sheet, when Sheet Thickness Lies in the Range .032 - .064 in.
These Curves Give Conservative Estimates for Conventional Values of Rivet Diameter, Sheet Thickness, and Rivet Pattern.
$\frac{\text{Net Area}}{\text{Gross Area}} \cong .75$
$0 < S_m < 15$ ksi
Plain
Dimpled
Countersunk
S_{max}
S_m
S_{min}
S_v
S_v
0
Gross Area Stress, S_v - ksi
0
5
10
15
20
25
10^3
10^4
10^5
10^6
10^7
Life Cycles, N

FIGURE 3.2

FIGURE 3.3

ALUMINUM ALLOY CYCLIC STRESS ALLOWABLES



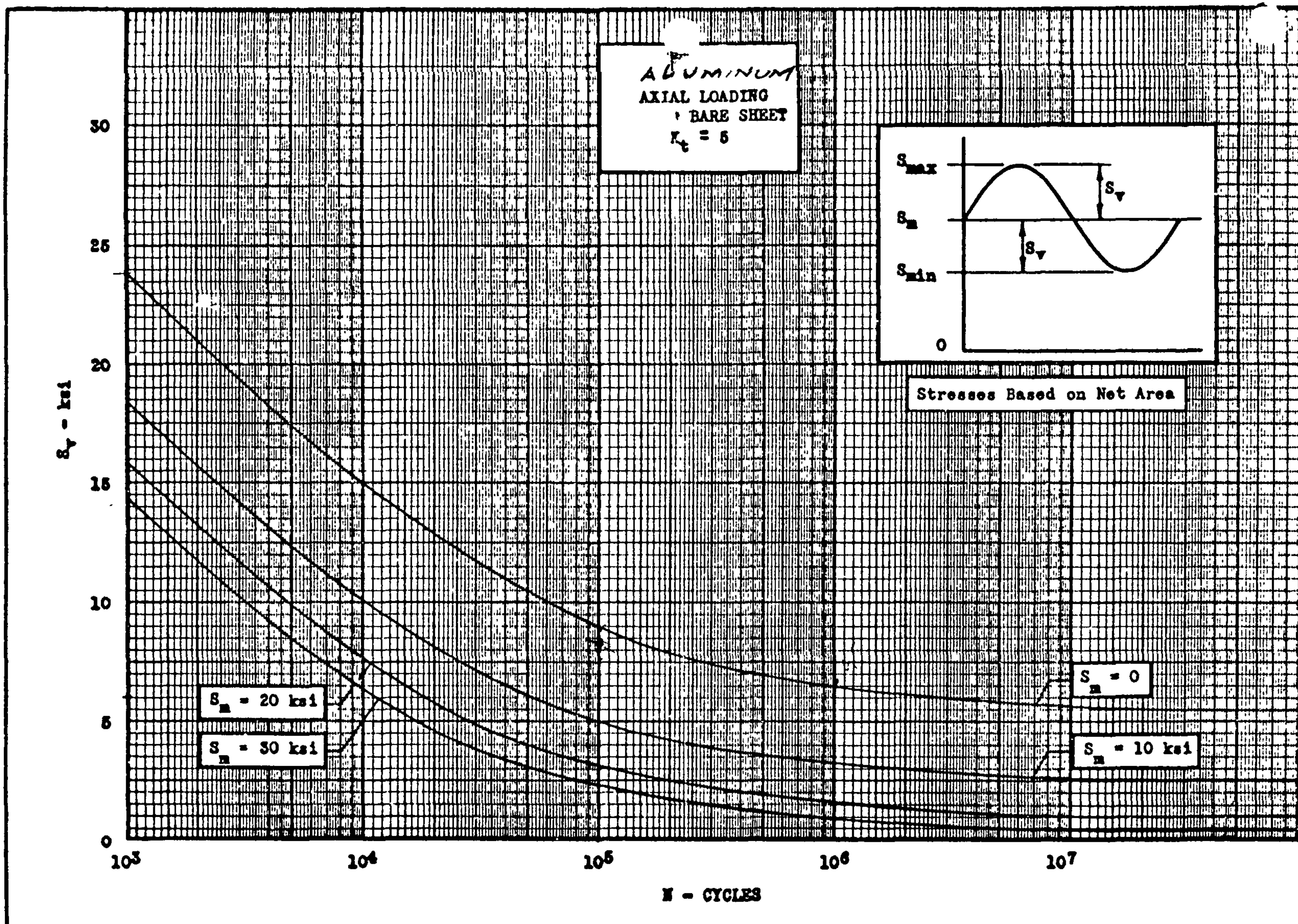

ALUMINUM
AXIAL LOADING
BARE SHEET
$K_t = 5$
S_{max}
S_m
S_{min}
S_v
S_v
0
Stresses Based on Net Area
$S_m = 0$
$S_m = 10$ ksi
$S_m = 20$ ksi
$S_m = 30$ ksi
S_v - ksi
30
25
20
15
10
5
0
10^3
10^4
10^5
10^6
10^7
N - CYCLES

FIGURE 3.4

LOAD MONITORING AND INSPECTION RECOMMENDATIONS

The blade strength level determination is based on analysis. The contract did not call for any structural proof or fatigue tests of full scale hardware. With this fact in mind, it is recommended that the blade and hub structure be periodically inspected to determine condition of the structure. Specific attention should be paid to the monolithic structural areas such as the root tubular flanged attachment extension and the aluminum machined plate root ribs. Attention should also be paid to the D section and aft skin section surface joints.

As part of the test program, the flap bending, chord bending and torsion loads at blade station 40 and 370 will be monitored. This monitoring will check the validity of the basic loads established for design. To maintain a watch on structural integrity the level of loads and cycles at that load need to be monitored to ensure the predicted fatigue allowables are not being exceeded.

The levels of load which should not be exceeded at the monitoring stations are as follows:

Flapwise Bending Moment In-Lbs.

	Normal Operation Stop/Start Steady + Cyclic	Cyclic Component 1/2 Peak to Peak $> 10^6$ Cycles	Max. Total Transient < 1000 Cycles
Sta. 40	700,000	350,000	1.5×10^6
Sta. 370	250,000	30,000	600,000

Chord Bending Moment In-Lbs.

	Normal Operation Stop/Start Steady + Cyclic	Cyclic Component 1/2 Peak to Peak $> 10^6$ Cycles	Max. Total Transient < 1000 Cycles
Sta. 40	600,000	450,000	2.2×10^6
Sta. 370	250,000	100,000	450,000

The above monitor loads should be used as a guide for exceedence of strength levels and fatigue damage appraisal. Inadvertant exceedence does not necessarily mean the blade is damaged but may be cause for inspection.

SECTION 3 APPENDIX A.

THIS APPENDIX CONTAINS THE OUTPUT DATA FOR THE MECHANIZED SECTION PROPERTY & INTERNAL LOADS PROGRAM.

BLADE SECTION PROPERTIES,

WINDMILL STA 48.00

INPUT DATA

GRID PT	X in	Z in	A in2	T in
1	-38.56	-2.50	0.53	0.08
2	-5.48	-11.81	1.89	0.25
3	0.95	-11.42	2.90	0.25
4	8.00	-8.68	3.19	0.25
5	12.14	-4.93	1.00	0.25
6	13.10	0.85	2.05	0.25
7	11.22	6.55	1.00	0.25
8	6.70	9.87	3.31	0.25
9	-0.98	11.72	2.75	0.25
10	-6.91	11.18	1.89	0.08
11	-38.56	-0.56	0.53	0.08
			Σ 21.04	

XLA in	ZLA in	XMS in	ZMS in	HMS in	TMS in	G	E
0.00	0.00	-6.18	0.00	22.99	0.25	4.00E+06	1.00E+07

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
0	10	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.60	0.22	1.88E+10	2.65E+10	2.20E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-40.16	-2.72	0.00	0.00	-0.02
2	-7.08	-12.03	0.00	0.00	-0.11
3	-0.65	-11.64	0.00	0.00	0.06
4	6.40	-8.90	0.00	0.00	0.22
5	10.54	-5.15	0.00	0.00	0.24
6	11.50	0.63	0.00	0.00	0.24
7	9.62	6.33	0.00	0.00	0.20
8	5.10	9.65	0.00	0.00	0.03
9	-2.58	11.50	0.00	0.00	-0.13
10	-8.51	10.96	0.00	0.00	-0.03
11	-40.16	-0.73	0.00	0.00	-0.03

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	741.18	809.39
correction shear flow	-0.23	-0.02
Q due to torsion	-0.01	-0.00

LATERAL LOCATION OF SHEAR CENTER AHEAD OF MID SPAR= 7.03

PREPARED BY A CHERRITT	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.3
CHECKED		TITLE 100 KW. WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

BLADE SECTION PROPERTIES.

WINDMILL STA 81.50

INPUT DATA

GRID PT	X in	Z in	A in2	T in
1	-38.40	-2.48	0.64	0.04
2	-6.66	-10.78	1.72	0.25
3	-0.14	-10.74	2.90	0.25
4	7.14	-8.45	3.10	0.25
5	11.53	-5.28	1.00	0.25
6	13.08	0.10	1.91	0.25
7	11.60	5.50	1.00	0.25
8	7.12	8.88	3.31	0.25
9	-0.42	10.80	2.75	0.25
10	-6.46	10.38	1.72	0.04
11	-38.40	-0.28	0.64	0.08
			Σ 20.78	

XLA in	ZLA in	XMS in	ZMS in	HMS in	TMS in	G	E
2.35	0.00	-6.57	0.00	21.10	0.125	4.00E+06	1.00E+07

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
0	10	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.02	-0.05	1.59E+10	2.93E+10	3.08E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.42	-2.43	0.00	0.00	-0.02
2	-7.68	-10.73	0.00	0.00	-0.11
3	-1.16	-10.69	0.00	0.00	0.09
4	6.12	-8.40	0.00	0.00	0.26
5	10.51	-5.23	0.00	0.00	0.29
6	12.06	0.15	0.00	0.00	0.30
7	10.58	5.55	0.00	0.00	0.26
8	6.10	8.93	0.00	0.00	0.08
9	-1.44	10.85	0.00	0.00	-0.11
10	-7.50	10.43	0.00	0.00	-0.03
11	-39.42	-0.23	0.00	0.00	-0.03

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	697.73	743.30
correction shear flow	-0.20	-0.02
q due to torsion	-0.03	-0.01

LATERAL LOCATION OF SHEAR CENTER AHEAD OF MID SPAR= 11.30

BLADE SECTION PROPERTIES.

WINDMILL STA 125

INPUT DATA

GRID PT	X In	Z In	A In2	T In
1	-38.12	-2.18	0.59	0.04
2	-7.68	-9.40	1.72	0.25
3.	-1.20	-9.48	2.85	0.25
4	6.32	-7.76	3.19	0.25
5	11.13	-4.83	1.25	0.25
6	13.30	-0.36	1.34	0.25
7	12.05	4.40	1.25	0.25
8	7.37	7.70	3.19	0.25
9	-0.08	9.47	2.85	0.25
10	-6.50	9.10	1.72	0.04
11	-38.12	-0.30	0.59	0.08
			Σ 20.54	

XLA In	ZLA In	XMS In	ZMS In	HMS In	TMS In	G	E
2.22	0.00	-7.09	0.00	18.50	0.08	4.00E+06	1.00E+07

SX lb	SZ lb	MX In-lb	MY In-lb	MZ In-lb
0	10	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.85	-0.16	1.24E+10	2.75E+10	1.28E+09

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-38.97	-2.02	0.00	0.00	-0.04
2	-8.53	-9.24	0.00	0.00	-0.12
3	-2.05	-9.32	0.00	0.00	0.09
4	5.47	-7.60	0.00	0.00	0.29
5	10.28	-4.67	0.00	0.00	0.35
6	12.45	-0.20	0.00	0.00	0.35
7	11.20	4.56	0.00	0.00	0.31
8	6.52	7.86	0.00	0.00	0.12
9	-0.93	9.63	0.00	0.00	-0.10
10	-7.35	9.26	0.00	0.00	-0.04
11	-38.97	-0.14	0.00	0.00	-0.04

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	632.44	630.93
correction shear flow	-0.19	-0.03
Q due to torsion	-0.05	-0.02

LATERAL LOCATION OF SHEAR CENTER AHEAD OF MID SPAR= 13.58

PREPARED BY	DATE	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.5
CHECKED		TITLE: 100 K.W. WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

Prepared by: A. Eckersett (signature), Date: 3/75

BLADE SECTION PROPERTIES

WINDMILL STA 187.5

INPUT DATA

GRID PT	X in	Z in	A in2	T in
1	-38.58	-1.03	0.32	0.04
2	-8.00	-7.62	1.72	0.25
3	-1.88	-7.70	2.00	0.25
4	5.72	-6.24	3.19	0.25
5	10.67	-4.38	1.25	0.25
6	13.02	0.08	1.54	0.25
7	10.68	4.65	1.25	0.25
8	6.58	6.44	2.67	0.25
9	-0.38	7.61	3.00	0.25
10	-7.32	7.30	1.72	0.04
11	-38.58	-0.42	0.32	0.08
		Σ	19.78	

XLA in	ZLA in	XMS in	ZMS in	HMS in	TMS in	G	E
1.83	0.00	-7.96	0.00	15.92	0.08	4.00E+06	1.00E+07

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
0	10	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.22	-0.12	8.21E+09	1.91E+10	8.50E+09

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.80	-1.51	0.00	0.00	-0.05
2	-9.82	-7.50	0.00	0.00	-0.16
3	-3.10	-7.67	0.00	0.00	0.30
4	4.50	-6.12	0.00	0.00	0.35
5	9.45	-4.26	0.00	0.00	0.42
6	11.80	0.20	0.00	0.00	0.43
7	9.46	4.77	0.00	0.00	0.36
8	5.36	6.56	0.00	0.00	0.15
9	-1.60	7.73	0.00	0.00	-0.13
10	-8.54	7.42	0.00	0.00	-0.04
11	-39.80	-0.30	0.00	0.00	-0.05

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	530.45	492.59
correction shear flow	-0.24	-0.03
q due to torsion	-0.06	-0.02

LATERAL LOCATION OF SHEAR CENTER AHEAD OF MID SPAR= 13.93

FORM 3628-2

BLADE SECTION PROPERTIES

WINDMILL STA 235.0

INPUT DATA

GRID PT	X in	Z in	A in2	T in
1	-36.25	-1.48	0.32	0.04
2	-8.22	-6.72	1.72	0.25
3	-2.27	-6.90	2.56	0.25
4	5.14	-4.82	3.19	0.25
5	10.10	-3.82	1.25	0.25
6	12.34	0.07	1.25	0.25
7	10.98	3.57	0.75	0.25
8	7.18	5.46	2.94	0.25
9	-0.15	6.77	3.00	0.25
10	-7.04	6.48	1.72	0.04
11	-36.25	-0.30	0.32	0.08
			19.02	

XLA in	ZLA in	XMS in	ZMS in	HMS in	TMS in	G	E
1.54	0.00	-7.63	0.00	15.26	0.08	4.00E+06	1.00E+07

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
0	10	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.95	0.02	5.99E+09	1.68E+10	9.24E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-37.20	-1.50	0.00	0.00	-0.06
2	-9.17	-6.74	0.00	0.00	-0.17
3	-3.22	-6.92	0.00	0.00	0.12
4	4.19	-4.84	0.00	0.00	0.39
5	9.15	-3.84	0.00	0.00	0.48
6	11.39	0.05	0.00	0.00	0.49
7	10.03	3.55	0.00	0.00	0.45
8	6.23	5.44	0.00	0.00	0.20
9	-1.10	6.75	0.00	0.00	-0.14
10	-7.99	6.46	0.00	0.00	-0.05
11	-37.20	-0.32	0.00	0.00	-0.06

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	439.20	410.51
correction shear flow	-0.28	-0.03
Q due to torsion	-0.07	-0.02

LATERAL LOCATION OF SHEAR CENTER AHEAD OF MID SPAR= 13.29

PREPARED BY a Blomquist	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.7
CHECKED		TITLE 100 KW. WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

BLADE SECTION PROPERTIES

WINDMILL STA 301

INPUT DATA

GRID PT	X In	Z In	A In2	T In
1	-33.10	-1.23	0.31	0.04
2	-6.92	-5.67	1.72	0.25
3	-1.42	-5.78	2.46	0.25
4	4.88	-4.86	2.69	0.25
5	8.81	-3.56	1.00	0.25
6	11.32	-0.40	1.15	0.25
7	9.72	3.16	1.00	0.25
8	6.19	4.62	2.69	0.25
9	-0.44	5.66	2.75	0.25
10	-6.94	5.40	1.72	0.04
11	-33.10	-0.20	0.31	0.08
			Σ 17.80	

XLA In	ZLA In	XMS In	ZMS In	HMS In	TMS In	G	E
1.14	0.00	-6.93	0.00	11.07	0.08	4.00E+06	1.00E+07

SX lb	SZ lb	MX In-lb	MY In-lb	MZ In-lb
0	10	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.69	-0.06	4.19E+09	1.32E+10	3.90E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-33.79	-1.17	0.00	0.00	-0.06
2	-7.61	-5.61	0.00	0.00	-0.21
3	-2.11	-5.72	0.00	0.00	0.12
4	4.19	-4.80	0.00	0.00	0.44
5	8.12	-3.50	0.00	0.00	0.53
6	10.63	-0.34	0.00	0.00	0.55
7	9.03	3.22	0.00	0.00	0.47
8	5.50	4.68	0.00	0.00	0.18
9	-1.13	5.72	0.00	0.00	-0.19
10	-7.63	5.46	0.00	0.00	-0.05
11	-33.79	-0.14	0.00	0.00	-0.06

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	344.97	316.67
correction shear flow	-0.35	-0.04
Q due to torsion	-0.08	-0.02

LATERAL LOCATION OF SHEAR CENTER AHEAD OF MID SPAR= 11.60

FORM 362B-2

BLADE SECTION PROPERTIES

WINDMILL STA 389.0

INPUT DATA

GRID PT	X In	Z In	A In2	T In
1	-28.80	-1.32	0.30	0.04
2	-5.70	-4.47	1.72	0.25
3	-1.30	-4.51	1.82	0.25
4	4.43	-3.74	3.19	0.25
5	8.94	-2.26	0.75	0.25
6	10.07	0.00	0.60	0.25
7	8.72	2.27	0.75	0.25
8	5.40	3.49	2.68	0.25
9	-0.14	4.33	2.25	0.25
10	-5.50	4.15	1.72	0.04
11	-28.80	-0.18	0.30	0.08
			Σ 16.08	

XLA In	ZLA In	XMS In	ZMS In	HMS In	TMS In	G	E
1.09	0.00	-5.60	0.00	11.20	0.08	4.00E+06	1.00E+07

SX lb	SZ lb	MX In-lb	MY In-lb	MZ In-lb
0	10	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.54	-0.13	2.28E+09	9.22E+09	2.52E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-29.34	-1.19	0.00	0.00	-0.08
2	-6.24	-4.34	0.00	0.00	-0.24
3	-1.84	-4.38	0.00	0.00	0.10
4	3.89	-3.61	0.00	0.00	0.63
5	8.40	-2.13	0.00	0.00	0.70
6	9.53	0.13	0.00	0.00	0.71
7	8.18	2.40	0.00	0.00	0.64
8	4.86	3.62	0.00	0.00	0.23
9	-0.68	4.46	0.00	0.00	-0.22
10	-6.04	4.28	0.00	0.00	-0.08
11	-29.34	-0.05	0.00	0.00	-0.09

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	227.33	226.28
correction shear flow	-0.43	-0.05
Q due to torsion	-0.13	-0.04

LATERAL LOCATION OF SHEAR CENTER AHEAD OF MID SPAR= 10.61

BLADE SECTION PROPERTIES

WINDMILL STA 477

INPUT DATA

GRID PT	X in	Z in	A in2	T in
1	-24.80	-0.90	0.27	0.04
2	-4.27	-3.27	1.72	0.25
3	-0.25	-3.26	1.73	0.25
4	4.42	-2.42	2.38	0.25
5	7.12	-1.95	0.60	0.25
6	8.48	-0.08	0.70	0.25
7	7.40	1.78	0.50	0.25
8	4.35	2.54	2.38	0.25
9	0.07	3.24	1.82	0.25
10	-4.19	3.10	1.72	0.04
11	-24.80	-0.20	0.27	0.08
			Σ 14.09	

XLA in	ZLA in	XMS in	ZMS in	HMS in	TMS in	G	E
1.04	0.00	-4.23	0.00	6.37	0.08	4.00E+06	1.00E+07

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
0	10	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.55	-0.03	1.05E+09	6.00E+09	1.27E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-25.35	-0.87	0.00	0.00	-0.08
2	-4.82	-3.24	0.00	0.00	-0.30
3	-0.80	-3.23	0.00	0.00	0.23
4	3.87	-2.39	0.00	0.00	0.79
5	6.57	-1.92	0.00	0.00	0.90
6	7.93	-0.05	0.00	0.00	0.92
7	6.85	1.81	0.00	0.00	0.84
8	4.30	2.57	0.00	0.00	0.23
9	-0.48	3.27	0.00	0.00	-0.28
10	-4.74	3.13	0.00	0.00	-0.08
11	-25.35	-0.17	0.00	0.00	-0.09

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	134.82	145.39
correction shear flow	-0.68	-0.06
Q due to torsion	-0.14	-0.03

LATERAL LOCATION OF SHEAR CENTER AHEAD OF MID SPAR= 7.65

BLADE SECTION PROPERTIES

WINDMILL STA 565

INPUT DATA

GRID PT	X in	Z in	A in2	T in
1	-21.17	-0.67	0.14	0.04
2	-3.08	-2.28	1.59	0.25
3	0.18	-2.22	1.31	0.25
4	4.09	-1.65	2.25	0.25
5	6.50	-1.21	0.37	0.25
6	7.27	-0.26	0.28	0.25
7	6.48	1.00	0.50	0.25
8	3.78	1.81	2.25	0.25
9	-0.05	2.18	1.31	0.25
10	-3.10	2.15	1.59	0.04
11	-21.17	-0.30	0.14	0.08
			Σ 11.73	

XLA in	ZLA in	XMS in	ZMS in	HMS in	TMS in	G	E
1.00	0.00	-3.09	0.00	4.43	0.08	4.00E+06	1.00E+07

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
0	10	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.84	-0.00	4.29E+08	2.68E+09	2.83E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-22.01	-0.67	0.00	0.00	-0.09
2	-3.92	-2.28	0.00	0.00	-0.39
3	-0.66	-2.22	0.00	0.00	0.28
4	3.25	-1.65	0.00	0.00	1.10
5	5.66	-1.21	0.00	0.00	1.27
6	6.43	-0.26	0.00	0.00	1.29
7	5.64	1.00	0.00	0.00	1.18
8	2.94	1.81	0.00	0.00	0.25
9	-0.89	2.18	0.00	0.00	-0.42
10	-3.94	2.15	0.00	0.00	-0.11
11	-22.01	-0.30	0.00	0.00	-0.11

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	74.49	86.79
correction shear flow	-1.04	-0.06
Q due to torsion	-0.20	-0.04

LATERAL LOCATION OF SHEAR CENTER AHEAD OF MID SPAR= 5.91

PREPARED BY a Elvrett	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.11
CHECKED		TITLE 100 KW WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

BLADE SECTION PROPERTIES

WINDMILL STA 609

INPUT DATA

GRID PT	X in	Z in	A in2	T in
1	-19.16	-0.78	0.14	0.04
2	-0.70	-1.84	1.56	0.25
3	2.09	-1.85	0.35	0.25
4	3.49	-1.50	0.75	0.37
5	4.85	-1.20	0.47	0.12
6	5.93	-1.02	0.12	0.12
7	6.55	-0.16	0.18	0.12
8	5.85	0.97	0.18	0.12
9	4.54	1.39	0.47	0.37
10	3.22	1.73	0.75	0.25
11	2.02	1.99	0.23	0.25
12	-0.48	1.87	1.56	0.04
13	-19.16	-0.48	0.14	0.12
			Σ 6.90	

XLA in	ZLA in	XMS in	ZMS in	HMS in	TMS in	G	E
1.00	0.00	-0.59	0.00	3.71	0.08	4.00E+06	1.00E+07

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
0	10	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.92	-0.00	1.87E+08	1.56E+09	4.18E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-20.08	-0.78	0.00	0.00	-0.13
2	-1.62	-1.84	0.00	0.00	-0.26
3	1.17	-1.85	0.00	0.00	0.09
4	2.57	-1.50	0.00	0.00	0.72
5	3.93	-1.20	0.00	0.00	1.05
6	5.01	-1.02	0.00	0.00	1.12
7	5.63	-0.16	0.00	0.00	1.15
8	4.93	0.97	0.00	0.00	1.07
9	3.62	1.39	0.00	0.00	0.74
10	2.30	1.73	0.00	0.00	0.37
11	1.10	1.99	0.00	0.00	-0.17
12	-1.40	1.87	0.00	0.00	-0.14
13	-20.08	-0.48	0.00	0.00	-0.15

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	43.68	74.33
correction shear flow	-1.50	-0.08
Q due to torsion	-0.23	-0.07

LATERAL LOCATION OF SHEAR CENTER AHEAD OF MID SPAR= 3.29

FORM 362B-2

BLADE SECTION PROPERTIES

WINDMILL STA 653

INPUT DATA

GRID PT	X In	Z In	A In2	T In
1	-17.08	-0.50	0.14	0.04
2	0.95	-1.52	0.37	0.37
3	1.86	-1.45	0.26	0.25
4	3.08	-1.33	0.40	0.12
5	4.42	-1.17	0.12	0.12
6	5.34	-0.86	0.12	0.12
7	5.88	-0.08	0.14	0.12
8	5.28	0.70	0.12	0.12
9	4.37	1.19	0.12	0.12
10	3.13	1.43	0.40	0.25
11	1.86	1.56	0.26	0.37
12	0.98	1.61	0.37	0.04
13	-17.08	-0.18	0.14	0.12
			Σ 2.96	

XLA In	ZLA In	XMS In	ZMS In	HMS In	TMS In	G	E
1.00	0.00	1.86	0.00	3.01	0.12	4.00E+06	1.00E+07

SX lb	SZ lb	MX In-lb	MY In-lb	MZ In-lb
0	10	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.88	-0.01	5.08E+07	1.06E+09	1.72E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-17.96	-0.49	0.00	0.00	-0.23
2	0.07	-1.51	0.00	0.00	0.89
3	0.98	-1.44	0.00	0.00	-0.87
4	2.20	-1.32	0.00	0.00	0.20
5	3.54	-1.16	0.00	0.00	0.50
6	4.46	-0.85	0.00	0.00	0.73
7	5.00	-0.07	0.00	0.00	0.78
8	4.40	0.71	0.00	0.00	0.62
9	3.49	1.20	0.00	0.00	0.34
10	2.25	1.44	0.00	0.00	-0.77
11	0.98	1.57	0.00	0.00	0.94
12	0.10	1.62	0.00	0.00	-0.26
13	-17.96	-0.17	0.00	0.00	-0.29

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	18.25	67.74
correction shear flow	-2.26	-0.11
Q due to torsion	-0.54	-0.18

LATERAL LOCATION OF SHEAR CENTER AHEAD OF MID SPAR= 1.36

BLADE SECTION PROPERTIES

WINDMILL STA 697

INPUT DATA

GRID PT	X in	Z in	A in2	T in
1	-14.97	-0.43	0.14	0.04
2	1.02	-1.20	0.37	0.37
3	1.85	-1.08	0.26	0.25
4	2.84	-1.12	0.25	0.12
5	3.80	-0.95	0.12	0.12
6	4.72	-0.72	0.10	0.12
7	5.20	-0.18	0.10	0.12
8	4.72	0.50	0.12	0.12
9	3.80	0.93	0.12	0.12
10	2.82	1.10	0.25	0.12
11	1.90	1.18	0.26	0.12
12	1.02	1.25	0.37	0.04
13	-14.97	-0.15	0.14	0.12
			2.60	

XLA in	ZLA in	XMS in	ZMS in	HMS in	TMS in	G	E
1.00	0.00	1.87	0.00	2.26	0.12	4.00E+06	1.00E+07

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
0	10	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.57	-0.03	2.74E+07	7.98E+08	1.17E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-15.54	-0.40	0.00	0.00	-0.31
2	0.45	-1.17	0.00	0.00	1.32
3	1.28	-1.05	0.00	0.00	-0.95
4	2.27	-1.09	0.00	0.00	0.08
5	3.23	-0.92	0.00	0.00	0.53
6	4.15	-0.69	0.00	0.00	0.80
7	4.63	-0.15	0.00	0.00	0.88
8	4.15	0.53	0.00	0.00	0.67
9	3.23	0.96	0.00	0.00	0.25
10	2.25	1.13	0.00	0.00	-0.75
11	1.33	1.21	0.00	0.00	1.41
12	0.45	1.28	0.00	0.00	-0.34
13	-15.54	-0.12	0.00	0.00	-0.40

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	11.70	47.67
correction shear flow	-3.00	-0.15
Q due to torsion	-0.69	-0.24

LATERAL LOCATION OF SHEAR CENTER AHEAD OF MID SPAR= 1.09

CASE 1. MEAN LOADS.

WINDMILL STA 48.00

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
280	9330	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.60	0.22	1.88E+10	2.65E+10	2.20E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-40.16	-2.72	0.00	0.00	-16.60
2	-7.08	-12.03	0.00	0.00	-102.21
3	-0.65	-11.64	0.00	0.00	64.65
4	6.40	-8.90	0.00	0.00	202.76
5	10.54	-5.15	0.00	0.00	227.12
6	11.50	0.63	0.00	0.00	218.36
7	9.62	6.33	0.00	0.00	186.13
8	5.10	9.65	0.00	0.00	26.73
9	-2.58	11.50	0.00	0.00	-128.68
10	-8.51	10.96	0.00	0.00	-30.08
11	-40.16	-0.78	0.00	0.00	-25.88

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	741.18	809.39
correction shear flow	-217.61	-22.96
Q due to torsion	-7.49	-2.91

MY @ shear center= -7910.11

sum 2A*q= 2.454E+05

Vertical imbalance= -0.00

q @ mid.spar= 199.23

PREPARED BY A. Sherrill	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.15
CHECKED		TITLE 100 KW. WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 1 MEAN LOADS

RIB REACT.@STA 81.50

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-68	-11920	0	6760	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.02	-0.05	1.59E+10	2.93E+10	9.08E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.42	-2.43	0.00	0.00	30.68
2	-7.68	-10.73	0.00	0.00	134.22
3	-1.16	-10.69	0.00	0.00	-97.65
4	6.12	-8.40	0.00	0.00	-302.75
5	10.51	-5.23	0.00	0.00	-344.17
6	12.06	0.15	0.00	0.00	-346.32
7	10.58	5.55	0.00	0.00	-307.39
8	6.10	8.93	0.00	0.00	-89.83
9	-1.44	10.85	0.00	0.00	134.67
10	-7.50	10.43	0.00	0.00	32.92
11	-39.42	-0.23	0.00	0.00	37.08

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	697.73	743.30
correction shear flow	237.47	26.34
Q due to torsion	38.85	10.74

MY @ shear center= 35095.47

sum 2A*q=-3.199E+05

Vertical inbalance= 0.00

q @ mid spar= -239.24

FORM 3628-2

PREPARED BY: a Cher… 3/75 (DATE)	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE: 3.A.16
CHECKED	TITLE: 100 K.W. WINDMILL BLADE.	MODEL: CL1708
APPROVED		REPORT NO. 27153

CASE 1. MEAN LOADS.

WINDMILL STA 81.50

SX lb	SZ lb	MX In-lb	MY In-lb	MZ In-lb
-1090	2665	305500	-6700	-38200

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.02	-0.05	1.59E+10	2.93E+10	9.08E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-39.42	-2.43	476.37	744.33	-18.15
2	-7.68	-10.73	3628.85	2109.80	-50.66
3	-1.16	-10.69	5962.39	2056.00	0.58
4	6.12	-8.40	4994.83	1565.78	54.37
5	10.51	-5.23	927.42	927.42	67.70
6	12.06	0.15	-218.15	-114.21	[illegible]
7	10.58	5.55	-1138.24	-1138.24	72.01
8	6.10	8.93	-5805.94	-1754.06	30.34
9	-1.44	10.85	-5688.45	-2068.53	-22.02
10	-7.50	10.43	-3345.72	-1345.18	0.32
11	-39.42	-0.23	206.64	322.87	-10.11

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	697.73	743.30
correction shear flow	-53.78	-6.07
Q due to torsion	-14.61	-4.04

MY @ shear center= -13136.87

sum 2A*q= 7.224E+04

Vertical imbalance= 0.00

q @ mid spar= 58.27

FORM 362B-2

CASE 1. MEAN LOADS.

WINDMILL STA 125

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-790	2760	287800	-1750	-52240

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.85	-0.16	1.24E+10	2.75E+10	1.28E+09

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-38.97	-2.02	464.25	786.86	-19.43
2	-8.53	-9.24	3787.38	2201.97	-46.42
3	-2.05	-9.32	6176.44	2167.17	11.35
4	5.47	-7.60	5450.69	1708.68	73.03
5	10.28	-4.67	1241.72	993.38	91.28
6	12.45	-0.20	-74.26	-55.42	98.44
7	11.20	4.56	-1428.75	-1143.00	91.06
8	6.52	7.86	-5951.45	-1865.66	42.57
9	-0.93	9.63	-6306.14	-2212.68	-20.49
10	-7.35	9.26	-3568.29	-2074.59	-4.27
11	-38.97	-0.14	208.42	353.25	-13.10

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	632.44	630.93
correction shear flow	-53.96	-7.96
Q due to torsion	-16.31	-5.14

MY @ shear center= -13561.03

sum 2A*q= 7.665E+04

Vertical imbalance= 0.00

q @ mid spar= 57.18

CASE 1. MEAN LOADS.

WINDMILL STA 187.5

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-450	2800	201600	-1100	-58270

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.22	-0.12	8.21E+09	1.91E+10	3.59E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.80	-1.51	358.75	1121.03	-17.01
2	-9.82	-7.59	4355.26	2532.71	-52.43
3	-3.10	-7.67	6937.84	2477.80	18.21
4	4.59	-6.12	5946.18	1864.01	91.08
5	9.45	-4.26	1493.67	1194.93	114.02
6	11.80	0.20	-393.25	-255.36	120.01
7	9.46	4.77	-2980.74	-1564.59	104.04
8	5.36	6.56	-5790.70	-2165.05	49.18
9	-1.60	7.73	-7253.74	-2422.91	-32.67
10	-8.54	7.42	-3805.41	-2212.45	-9.10
11	-39.80	-0.30	236.14	737.94	-13.72

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	530.45	492.59
correction shear flow	-67.97	-8.26
Q due to torsion	-10.07	-5.46

MY @ shear center= -12805.83

sum 2A*q= 7.915E+04

Vertical imbalance= 0.00

q @ mid spar= 73.31

PREPARED BY	DATE	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE
A. Elliott	3/75		3.A 19
CHECKED		TITLE: 100 KW WINDMILL BLADE	MODEL: CL1708
APPROVED			REPORT NO. 27153

CASE 1. MEAN LOADS.

WINDMILL STA 235.0

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-235	2750	241200	-780	-54300

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.95	0.02	5.99E+09	1.68E+10	9.24E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-37.20	-1.50	314.20	981.87	-18.88
2	-9.17	-6.74	4805.46	2793.87	-54.21
3	-3.22	-6.92	7180.60	2804.92	24.64
4	4.19	-4.84	6046.27	1895.38	102.20
5	9.15	-3.84	1804.70	1443.76	129.45
6	11.39	0.05	-172.50	-138.00	135.27
7	10.03	3.55	-1144.90	-1526.53	126.12
8	6.23	5.44	-6599.91	-2244.87	59.55
9	-1.10	6.75	-8083.67	-2694.56	-36.13
10	-7.99	6.46	-4313.12	-2507.63	-11.33
11	-37.20	-0.32	162.89	509.03	-15.99

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	439.20	410.51
correction shear flow	-76.63	-9.62
Q due to torsion	-21.80	-6.37

MY @ shear center= -12191.22

sum 2A*q= 7.423E+04

vertical imbalance= -0.00

q @ mid spar= 32.45

FORM 362B-2

PREPARED BY a. Chu...tt	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.20
CHECKED		TITLE 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 1. MEAN LOADS.

WINDMILL STA 301

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-175	2620	212850	-100	-43300

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.69	-0.06	4.19E+09	1.32E+10	3.90E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-33.79	-1.17	369.14	1190.77	-16.18
2	-7.61	-5.61	5107.07	2969.23	-58.53
3	-2.11	-5.72	7200.88	2927.19	28.03
4	4.19	-4.80	6323.10	2350.60	112.53
5	8.12	-3.50	1624.09	1624.09	137.04
6	10.63	-0.34	-19.41	-16.88	143.35
7	9.03	3.22	-1786.99	-1786.99	126.02
8	5.50	4.68	-6622.60	-2461.93	51.79
9	-1.13	5.72	-7891.61	-2869.68	-47.79
10	-7.63	5.46	-4511.50	-2622.97	-12.10
11	-33.79	-0.14	207.83	670.42	-15.14

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	344.97	316.67
correction shear flow	-91.91	-9.48
Q due to torsion	-21.93	-5.66

MY @ shear center= -9358.65

sum 2A*q= 6.510E+04

Vertical imbalance= -0.00

q @ mid spar= 98.70

FORM 362B-2

PREPARED BY a Cherrett	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.21
CHECKED		TITLE 100 K.W. WINMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 1. MEAN LOADS.

WINDMILL STA 389.0

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
50	2330	169000	-190	-34260

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.54	-0.13	2.28E+09	9.22E+09	2.52E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-29.34	-1.19	413.10	1376.99	-19.43
2	-6.24	-4.34	5694.63	3310.83	-55.89
3	-1.84	-4.38	5943.97	3265.92	24.93
4	3.89	-3.61	8296.38	2600.75	145.59
5	8.40	-2.13	1074.19	1432.26	163.38
6	9.53	0.13	-152.80	-254.67	163.89
7	8.18	2.40	-1430.27	-1907.03	146.90
8	4.86	3.62	-7373.19	-2751.19	50.73
9	-0.68	4.46	-7374.08	-3277.37	-52.14
10	-6.04	4.28	-5252.64	-3053.86	-19.28
11	-29.34	-0.05	160.71	535.71	-21.10

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	227.33	226.28
correction shear flow	-99.59	-12.03
Q due to torsion	-31.94	-9.07

MY @ shear center= -9314.15

sum 2A*q= 5.007E+04

Vertical imbalance= 0.00

q @ mid spar= 110.43

FORM 362B-2

PREPARED BY	DATE	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE
A Elerrett	3/75		3.A.22
CHECKED		TITLE: 100 K.W. WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE I. MEAN LOADS.

WINDMILL STA 477

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
95	1905	117000	-80	-23140

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.55	-0.03	1.05E+09	6.00E+09	1.27E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-25.35	-0.87	363.97	1348.05	-14.39
2	-4.82	-3.24	6283.93	3653.45	-55.00
3	-0.80	-3.23	6195.91	3581.45	45.55
4	3.87	-2.39	6148.01	2583.20	150.31
5	6.57	-1.92	1214.00	2023.33	172.00
6	7.93	-0.05	-43.36	-61.94	173.91
7	6.85	1.81	-1049.59	-2099.18	158.38
8	4.30	2.57	-6901.11	-2899.62	50.49
9	-0.48	3.27	-6552.02	-3600.01	-56.94
10	-4.74	3.13	-5815.05	-3380.84	-16.42
11	-25.35	-0.17	155.30	575.18	-17.11

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	134.82	145.39
correction shear flow	-129.15	-10.69
Q due to torsion	-27.30	-6.42

MY @ shear center= -4612.98

sum 2A*q= 3.353E+04

Vertical imbalance= -0.00

q @ mid spar= 139.34

FORM 362B-2

PREPARED BY a Schmitt	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.23
CHECKED		TITLE 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 1. MEAN LOADS.

WINDMILL STA 565

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
100	1100	64160	70	-12450

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.84	-0.00	4.29E+08	2.68E+09	2.83E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-22.01	-0.67	233.19	1665.64	-8.89
2	-3.92	-2.28	5589.79	3515.59	-38.83
3	-0.66	-2.22	4357.57	3326.39	35.60
4	3.25	-1.65	5301.29	2356.13	129.68
5	5.66	-1.21	601.53	1625.75	140.89
6	6.43	-0.26	51.61	184.32	142.54
7	5.64	1.00	-836.05	-1672.10	129.39
8	2.94	1.31	-6296.63	-2798.50	24.12
9	-0.89	2.18	-4236.09	-3233.66	-49.08
10	-3.94	2.15	-4922.07	-3095.64	-12.97
11	-22.01	-0.30	155.88	1113.41	-11.59

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	74.49	36.79
correction shear flow	-114.13	-7.13
Q due to torsion	-20.70	-4.46

MY @ shear center= -1929.28

sum 2A*q= 1.561E+04

Vertical imbalance= -0.00

q @ mid spar= 123.24

FORM 362B-2

PREPARED BY: (signature) DATE: 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE: 3.A.24
CHECKED	TITLE: 100 KW WINDMILL BLADE.	MODEL: CL1708
APPROVED		REPORT NO. 27153

CASE 1. MEAN LOADS

WINDMILL STA. 609

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
85	1055	40000	75	-7950

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.92	-0.00	1.87E+08	1.56E+09	4.18E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-20.08	-0.78	213.97	1528.36	-11.91
2	-1.62	-1.84	6086.07	3991.33	-23.29
3	1.17	-1.85	1378.93	3939.81	13.52
4	2.57	-1.50	2491.81	3202.42	78.62
5	3.93	-1.20	1208.53	2571.35	112.07
6	5.01	-1.02	263.32	2194.33	119.52
7	5.63	-0.16	65.72	365.09	122.07
8	4.93	0.97	-363.60	-2047.77	113.03
9	3.62	1.39	-1386.99	-2951.04	77.70
10	2.30	1.73	-2762.90	-3683.87	5.98
11	1.10	1.99	-976.45	-4245.43	-19.66
12	-1.40	1.87	-6247.87	-4005.04	-16.35
13	-20.08	-0.48	124.45	888.93	-15.32

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	43.68	74.33
correction shear flow	-157.96	-8.57
Q due to torsion	-27.73	-6.75

MY @ shear center= -1713.02

sum 2A*q= 1.100E+04

Vertical imbalance= -0.00

q @ mid spar= 170.37

CASE I. MEAN LOADS.

WINDMILL STA 653

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
60	740	19800	120	-4570

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.88	-0.01	5.08E+07	1.06E+09	1.72E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-17.96	-0.49	217.85	1556.10	-14.80
2	0.07	-1.51	2213.34	5902.24	68.15
3	0.98	-1.44	1468.42	5647.77	-60.15
4	2.20	-1.32	2081.84	5204.61	18.77
5	3.54	-1.16	575.98	4607.87	40.81
6	4.46	-0.85	427.19	3417.51	57.40
7	5.00	-0.07	52.91	386.21	60.10
8	4.40	0.71	-333.54	-2668.34	48.18
9	3.49	1.20	-574.76	-4598.10	27.11
10	2.25	1.44	-2223.79	-5559.48	-55.27
11	0.98	1.57	-1584.03	-6092.44	69.23
12	0.10	1.62	-2364.53	-6305.41	-19.32
13	-17.96	-0.17	43.12	307.97	-20.33

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	18.25	67.74
correction shear flow	-166.95	-7.91
Q due to torsion	-36.96	-12.43

MY @ shear center= -1516.45

sum 2A*q= 4.583E+03

Vertical imbalance= 0.00

q @ mid spar= 183.58

CASE 1. MEAN LOADS.

WINDMILL STA 697

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-40	400	8470	200	-2270

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.57	-0.03	2.74E+07	7.98E+08	1.17E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-15.54	-0.40	137.64	983.18	-10.90
2	0.45	-1.17	1364.74	3639.30	54.21
3	1.28	-1.05	853.27	3281.82	-31.97
4	2.27	-1.09	855.63	3422.50	9.70
5	3.23	-0.92	364.05	2912.39	27.74
6	4.15	-0.69	221.58	2215.81	39.03
7	4.63	-0.15	55.18	551.79	42.50
8	4.15	0.53	-195.26	-1562.06	34.19
9	3.23	0.96	-363.66	-2909.24	17.67
10	2.25	1.13	-863.08	-3452.32	-22.27
11	1.33	1.21	-966.08	-3715.69	59.82
12	0.45	1.28	-1480.28	-3947.40	-10.15
13	-15.54	-0.12	16.26	116.13	-13.41

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	11;70	47.67
correction shear flow	-120.13	-6.20
Q due to torsion	-20.60	-7.21

MY @ shear center= -584.79

sum 2A*q= 2.138E+03

Vertical imbalance= 0.00

q @ mid spar= 127.32

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CHECKED		TITLE 100 KW. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 2. MEAN LOADS.

WINDMILL STA 43.00

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-42690	16500	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.60	0.22	1.88E+10	2.65E+10	2.20E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-40.16	-2.72	0.00	0.00	-379.44
2	-7.08	-12.03	0.00	0.00	-797.47
3	-0.65	-11.64	0.00	0.00	-532.48
4	6.40	-8.90	0.00	0.00	44.69
5	10.54	-5.15	0.00	0.00	259.47
6	11.50	0.63	0.00	0.00	627.78
7	9.62	6.33	0.00	0.00	727.30
8	5.10	9.65	0.00	0.00	719.62
9	-2.58	11.50	0.00	0.00	328.62
10	-8.51	10.96	0.00	0.00	289.84
11	-40.16	-0.78	0.00	0.00	-49.30

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	741.18	809.39
correction shear flow	-433.30	-42.50
Q due to torsion	-17.49	-6.79

MY @ shear center= -18464.90

sum 2A*q= 4.759E+05

Vertical imbalance= -0.00

q @ mid spar= 401.49

FORM 362B-2

CASE 2. MEAN LOADS.

RIB REACT.@STA 81.50

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
46100	-25060	0	47500	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.02	-0.05	1.59E+10	2.93E+10	9.08E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.42	-2.43	0.00	0.00	479.84
2	-7.68	-10.73	0.00	0.00	940.08
3	-1.16	-10.69	0.00	0.00	477.63
4	6.12	-8.40	0.00	0.00	-285.43
5	10.51	-5.23	0.00	0.00	-542.89
6	12.06	0.15	0.00	0.00	-911.26
7	10.58	5.55	0.00	0.00	-990.13
8	6.10	8.93	0.00	0.00	-824.46
9	-1.44	10.85	0.00	0.00	-262.95
10	-7.50	10.43	0.00	0.00	-309.00
11	-39.42	-0.23	0.00	0.00	97.15

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	697.73	743.30
correction shear flow	527.94	63.07
Q due to torsion	123.26	54.08

MY @ shear center= 111350.37

sum 2A*q=-7.026E+05

Vertical imbalance= 0.00

q @ mid spar= -554.04

CASE 2. MEAN LOADS.

WINDMILL STA 81.50

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-5165	4590	675400	-47590	1359000

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.02	-0.05	1.595+10	2.935+10	9.08E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-30.42	-2.43	-11242.81	-17568.90	-71.04
2	-7.68	-10.73	2078.73	1208.57	-171.11
3	-1.16	-10.69	12405.15	4277.64	-84.63
4	6.12	-8.40	21343.08	6090.81	31.60
5	10.51	-5.23	7338.33	7339.33	66.68
6	12.66	0.15	10778.98	5643.45	108.43
7	10.38	5.55	2504.87	2504.87	111.40
8	6.10	8.93	-3780.79	-1142.23	60.37
9	-1.44	10.85	-15342.52	-5579.13	-36.15
10	-7.59	10.43	-14295.17	-8258.82	17.18
11	-30.42	-0.23	-11978.45	-19560.08	-29.03

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	697.73	743.30
correction shear flow	-34.66	-11.01
q due to torsion	-65.20	-18.03

MY @ shear center= -58889.20

sum 2A*q= 1.265E+05

Vertical Imbalance= 0.00

q @ mid spar= 139.83

FORM 362B-2

CASE 2. MEAN LOADS.

WINDMILL STA 125

SX lb	SZ lb	MX In-lb	MY In-lb	MZ In-lb
-4640	4910	698700	-43040	1129000

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.85	-0.16	1.24E+10	2.75E+10	1.28E+09

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-38.97	-2.02	-9358.49	-15861.85	-77.62
2	-8.53	-9.24	3221.17	1872.77	-174.64
3	-2.05	-9.32	13575.25	4763.25	-75.52
4	5.47	-7.60	22383.20	7016.68	57.78
5	10.28	-4.67	9183.45	7346.76	106.13
6	12.45	-0.20	7482.27	5583.78	138.61
7	11.20	4.56	2681.00	2144.80	141.33
8	6.52	7.86	-6098.59	-1911.78	76.57
9	-0.93	9.63	-17823.94	-6254.01	-42.09
10	-7.35	9.26	-15213.20	-8844.89	3.51
11	-38.97	-0.14	-10032.11	-17003.58	-39.35

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	632.44	630.93
correction shear flow	-97.50	-15.02
Q due to torsion	-77.18	-24.33

MY @ shear center= -64160.88

sum 2A*q= 1.379E+05

Vertical Imbalance= 0.00

q @ mid spar= 135.32

PREPARED BY	DATE	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE
a Blevritt	3/75		3.A.31
CHECKED		TITLE: 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 2. MEAN LOADS.

WINDMILL STA 187.5

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-3810	4990	662810	-37000	862200

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.22	-0.12	8.21E+09	1.91E+10	8.59E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.80	-1.51	-5797.86	-18118.31	-65.82
2	-9.82	-7.59	2822.53	1641.01	-190.95
3	-3.1[illegible]	-7.67	[illegible]180.25	5064.33	-75.17
4	4.50	-6.12	23739.59	7441.88	80.53
5	9.45	-4.26	10326.28	8261.03	140.90
6	11.80	0.20	8596.75	5582.30	180.15
7	9.46	4.77	652.21	521.77	169.33
8	5.36	6.55	[illegible]	-3013.05	91.24
9	-1.60	7.73	-22233.23	-7411.08	-66.01
10	-8.54	7.42	-18111.77	-10530.19	-11.69
11	-39.80	-0.30	-6123.92	-19155.01	-39.98

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	530.45	432.59
correction shear flow	-122.02	-15.31
q due to torsion	-86.15	-24.67

MY @ shear center= -57850.23

sum 2A*q= 1.419E+05

Vertical imbalance= 0.00

q @ mid spar= 168.19

FORM 362B-2

CASE 2. MEAN LOADS.

WINDMILL STA 235.0

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-3340	4840	599500	-32230	700800

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.95	0.02	5.99E+09	1.68E+10	9.24E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-37.20	-1.50	-5145.30	-16079.06	-70.38
2	-9.17	-6.74	4937.05	2870.38	-197.02
3	-3.22	-6.92	15084.28	5892.30	-67.58
4	4.19	-4.84	22913.69	7182.98	95.55
5	9.15	-3.84	10584.87	8467.89	164.09
6	11.39	0.05	6697.77	5358.21	198.40
7	10.03	3.55	716.67	955.55	194.30
8	6.23	5.44	-8465.23	-2879.33	103.94
9	-1.10	6.75	-23310.03	-7770.01	-75.32
10	-7.99	6.46	-18463.23	-10734.44	-16.98
11	-37.20	-0.32	-5550.53	-17345.39	-45.27

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	439.20	410.51
correction shear flow	-136.43	-17.59
Q due to torsion	-94.78	-27.68

MY @ shear center= -52989.36

sum 2A*q= 1.322E+05

Vertical imbalance= 0.00

q @ mid spar= 185.93

CASE 2. MEAN LOADS.

WINDMILL STA 301

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-2875	4500	496980	-25800	518210

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.69	-0.06	4.19E+09	1.32E+10	3.90E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-33.79	-1.17	-4020.07	-12967.97	-63.93
2	-7.61	-5.61	6224.59	3618.95	-206.70
3	-2.11	-5.72	14999.33	6097.29	-65.57
4	4.19	-4.80	20596.78	7656.80	103.82
5	8.12	-3.50	7741.57	7741.57	162.32
6	10.63	-0.34	5688.27	4946.32	197.01
7	9.03	3.22	-89.61	-89.61	184.22
8	5.50	4.68	-9091.07	-3379.58	83.20
9	-1.13	5.72	-20561.53	-7476.92	-96.71
10	-7.63	5.46	-17077.67	-9928.88	-16.28
11	-33.79	-0.14	-4410.60	-14227.73	-41.85

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	344.97	316.67
correction shear flow	-159.65	-16.54
Q due to torsion	-98.06	-25.32

MY @ shear center= -41844.33

sum 2A*q= 1.126E+05

Vertical imbalance= -0.00

q @ mid spar= 215.86

CASE 2. MEAN LOADS.

WINDMILL STA 389.0

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-2125	3830	354150	-19300	323000

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.54	-0.13	2.28E+09	9.22E+09	2.52E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-29.34	-1.19	-2895.17	-9650.56	-71.88
2	-6.24	-4.34	7682.34	4466.48	-203.62
3	-1.84	-4.38	11398.33	6262.82	-76.69
4	3.89	-3.61	23260.75	7291.77	154.51
5	8.40	-2.13	5031.46	6708.61	199.29
6	9.53	0.13	2130.74	3551.23	213.84
7	8.18	2.40	-448.98	-598.64	200.15
8	4.86	3.62	-10319.57	-3850.59	70.76
9	-0.68	4.46	-16584.73	-7370.99	-104.67
10	-6.04	4.28	-15814.86	-9194.68	-29.48
11	-29.34	-0.05	-3440.30	-11467.67	-53.60

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	227.33	226.28
correction shear flow	-165.34	-20.14
q due to torsion	-117.82	-33.46

MY @ shear center= -34353.83

sum 2A*q= 8.282E+04

Vertical imbalance= 0.00

q @ mid spar= 229,56

PREPARED BY a [signature]	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.35
CHECKED		TITLE 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 2. MEAN LOADS.

WINDMILL STA 477

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-1510	2990	222000	-13040	176900

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.55	-0.03	1.05E+09	6.00E+09	1.27E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-25.35	-0.87	-1823.28	-6752.89	-59.87
2	-4.82	-3.24	9114.00	5298.84	-205.48
3	-0.80	-3.23	11495.03	6644.53	-49.63
4	3.87	-2.39	15316.87	6435.66	142.24
5	6.57	-1.92	3809.03	6348.59	187.59
6	7.93	-0.05	1967.30	2810.44	205.99
7	6.85	1.31	-767.95	-1535.90	190.81
8	4.30	2.57	-9588.85	-4028.93	47.81
9	-0.48	3.27	-13016.56	-7151.96	-125.19
10	-4.74	3.13	-14277.99	-8301.16	-25.21
11	-25.35	-0.17	-2227.61	-8250.39	-45.24

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	134.82	145.39
correction shear flow	-204.73	-17.04
Q due to torsion	-119.98	-28.20

MY @ shear center= -20275.18

sum 2A*q= 5.307E+04

Vertical imbalance= 0.00

q @ mid spar= 279.47

FORM 362B-2

CASE 2. MEAN LOADS.

WINDMILL STA 565

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-970	2075	102550	-5570	78850

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.84	-0.00	4.29E+08	2.68E+09	2.83E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-22.01	-0.67	-757.13	-5408.09	-43.47
2	-3.92	-2.28	6734.24	4235.37	-175.73
3	-0.66	-2.22	6719.58	5129.45	-38.21
4	3.25	-1.65	11253.65	5001.62	171.89
5	5.66	-1.21	1742.39	4709.15	202.20
6	6.43	-0.26	746.24	2665.15	213.09
7	5.64	1.00	-311.46	-622.92	200.30
8	2.94	1.81	-7729.01	-3435.12	29.12
9	-0.89	2.18	-7266.60	-5547.03	-114.77
10	-3.94	2.15	-10249.92	-6446.49	-24.62
11	-22.01	-0.30	-881.96	-6299.73	-35.31

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	74.49	86.79
correction shear flow	-216.93	-13.58
Q due to torsion	-100.83	-21.72

MY @ shear center= -9395.83

sum 2A*q= 2.965E+04

Vertical imbalance= -0.00

q @ mid spar= 282.45

CASE 2. MEAN LOADS.

WINDMILL STA 609

SX lb	SZ lb	MX In-lb	MY In-lb	MZ In-lb
-515	1600	72100	-5270	46250

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.92	-0.00	1.87E+08	1.56E+09	4.18E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-20.08	-0.78	-701.69	-5012.10	-51.29
2	-1.62	-1.84	10230.17	6557.80	-145.09
3	1.17	-1.85	2700.71	7716.32	-86.97
4	2.57	-1.50	5177.14	6902.85	20.76
5	3.93	-1.20	2946.80	6269.79	79.66
6	5.01	-1.02	719.50	5995.85	93.56
7	5.63	-0.16	515.84	2865.80	101.66
8	4.93	0.97	-333.82	-1854.56	91.46
9	3.62	1.39	-1894.18	-4030.18	44.31
10	2.30	1.75	-4421.62	-5895.50	-58.53
11	1.10	1.99	-1701.63	-7398.38	-96.78
12	-1.40	1.87	-12370.51	-7929.81	-34.87
13	-20.08	-0.48	-866.70	-6190.74	-44.99

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	43.68	74.33
correction shear flow	-241.82	-13.22
q due to torsion	-130.14	-31.68

MY @ shear center= -8039.13

sum 2A*q= 1.685E+04

Vertical imbalance= -0.00

q @ mid spar= 327.07

CASE 2. MEAN LOADS.

WINDMILL STA 653

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-485	1130	37400	-3190	22800

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.88	-0.01	5.08E+07	1.06E+09	1.72E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-17.96	-0.49	-329.77	-2355.47	-64.37
2	0.07	-1.51	4246.06	11322.83	63.50
3	0.98	-1.44	2887.54	11105.92	-187.62
4	2.20	-1.32	4247.91	10619.78	-61.32
5	3.54	-1.16	1234.40	9875.23	-24.97
6	4.46	-0.85	983.65	7869.24	3.60
7	5.00	-0.07	304.87	2225.32	11.49
8	4.40	0.71	-475.22	-3801.78	-3.88
9	3.49	1.20	-970.90	-7767.22	-33.96
10	2.25	1.44	-3990.59	-9976.46	-155.89
11	0.98	1.57	-2957.31	-11374.25	92.15
12	0.10	1.62	-4516.30	-12043.47	-43.98
13	-17.96	-0.17	-664.35	-4745.39	-59.22

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	18.25	67.74
correction shear flow	-257.03	-12.20
Q due to torsion	-139.80	-47.01

MY @ shear center= -5736.67

sum 2A*q= 7.093E+03

Vertical imbalance= 0.00

q @ mid spar= 337.62

CASE 2. MEAN LOADS.

WINDMILLSTA 697

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-220	770	17500	-1680	10300

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.57	-0.03	2.74E+07	7.98E+08	1.17E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-15.54	-0.40	-122.12	-872.27	-50.45
2	0.45	-1.17	2887.11	7698.97	75.54
3	1.28	-1.05	1847.95	7107.49	-137.65
4	2.27	-1.09	1897.11	7588.46	-56.19
5	3.23	-0.92	837.77	6702.18	-20.66
6	4.15	-0.69	541.82	5418.21	1.87
7	4.63	-0.15	202.73	2027.27	9.41
8	4.15	0.53	-310.72	-2485.78	-5.70
9	3.23	0.96	-684.72	-5477.74	-36.86
10	2.25	1.13	-1699.67	-6798.69	-112.95
11	1.33	1.21	-1956.01	-7523.12	93.54
12	0.45	1.28	-3065.17	-8173.80	-41.22
13	-15.54	-0.12	-376.08	-2686.30	-51.40

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	11.70	47.67
correction shear flow	-232.02	-11.99
Q due to torsion	-112.55	-39.41

MY @ shear center= -3195.83

sum 2A*q= 4.133E+03

Vertical imbalance= 0.00

q @ mid spar= 293.17

CASE 3. MEAN LOADS.

WINDMILL STA 48.00

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
77760	-56930	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.60	0.22	1.88E+10	2.65E+10	2.20E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-40.16	-2.72	0.00	0.00	745.60
2	-7.08	-12.03	0.00	0.00	1759.10
3	-0.65	-11.64	0.00	0.00	795.44
4	6.40	-8.90	0.00	0.00	-660.66
5	10.54	-5.15	0.00	0.00	-1125.40
6	11.50	0.63	0.00	0.00	-1778.18
7	9.62	6.33	0.00	0.00	-1869.38
8	5.10	9.65	0.00	0.00	-1400.51
9	-2.58	11.50	0.00	0.00	-237.64
10	-8.51	10.96	0.00	0.00	-447.56
11	-40.16	-0.78	0.00	0.00	164.54

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	741.18	809.39
correction shear flow	1418.16	143.73
Q due to torsion	53.57	20.80

MY @ shear center= 56545.21

sum 2A*q=-1.576E+06

Vertical imbalance= -0.00

q @ mid spar= -1307.19

CASE 3. MEAN LOADS.

RIB REACT.@STA. 81.50

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-76010	71090	0	-157900	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.02	-0.05	1.59E+10	2.93E+10	9.08E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.42	-2.43	0.00	0.00	-888.47
2	-7.68	-10.73	0.00	0.00	-1956.93
3	-1.16	-10.69	0.00	0.00	-615.41
4	6.12	-8.40	0.00	0.00	1156.18
5	10.51	-5.23	0.00	0.00	1684.77
6	12.06	0.15	0.00	0.00	2300.10
7	10.58	5.55	0.00	0.00	2332.23
8	6.10	8.93	0.00	0.00	1516.78
9	-1.44	10.85	0.00	0.00	29.44
10	-7.50	10.43	0.00	0.00	409.50
11	-39.42	-0.23	0.00	0.00	-272.03

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	697.73	743.30
correction shear flow	*******	-169.81
Q due to torsion	-369.70	-102.22

MY @ shear center=-333929.08

sum 2A*q= 1.957E+06

Vertical imbalance= 0.00

q @ mid spar= 1561.32

PREPARED BY	DATE	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE
A Schmitt	3/75		3.A.42
CHECKED		TITLE: 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 3, MEAN LOADS

WINDMILL STA 81.50

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
3095	-7010	-2114700	157900	-2376000

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.02	-0.05	1.59E+10	2.93E+10	9.08E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.42	-2.43	19326.90	30198.27	100.51
2	-7.68	-10.73	-14182.50	-8245.64	303.54
3	-1.16	-10.69	-39843.46	-13730.12	169.36
4	6.12	-8.40	-53528.51	-15780.10	19.79
5	10.51	-5.23	-16149.49	-10149.49	-19.44
6	12.06	0.15	-19219.49	-10057.85	-52.66
7	10.58	5.55	-1360.09	-1360.09	-43.58
8	6.10	8.93	23528.24	7108.23	58.91
9	-1.44	10.85	44406.27	10109.55	198.83
10	-7.50	10.43	35686.80	20748.14	32.59
11	-39.42	-0.23	21268.35	33226.08	69.71

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	697.73	743.30
correction shear flow	142.15	16.16
q due to torsion	193.67	53.55

MY @ shear center= 174935.38

sum 2A*q=-1.907E+05

Vertical imbalance= 0.00

q @ mid spar= -266.12

FORM 362B-2

PREPARED BY a Cleveritt	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.43
CHECKED		TITLE 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 3. MEAN LOADS

WINDMILL STA 125

SX lb	SZ lb	MX In-lb	MY In-lb	MZ In-lb
3230	-7340	-2077700	146570	-1891200

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.85	-0.16	1.24E+10	2.75E+10	1.28E+09

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-38.97	-2.02	15588.03	26420.39	115.23
2	-8.53	-9.24	-16552.30	-9623.43	309.53
3	-2.05	-9.32	-42025.35	-14745.74	157.17
4	5.47	-7.60	-55877.80	-17516.55	-15.09
5	10.28	-4.67	-20106.85	-16085.48	-69.17
6	12.45	-0.20	-13304.39	-9928.65	-95.11
7	11.20	4.56	-793.25	-634.60	-81.02
8	6.52	7.86	27882.99	8740.75	40.43
9	-0.93	9.63	50067.12	17567.41	210.40
10	-7.35	9.26	37591.99	21855.81	56.01
11	-38.97	-0.14	17529.82	29711.56	88.98

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	632.44	630.93
correction shear flow	144.04	21.47
Q due to torsion	214.13	67.51

MY @ shear center= 178018.62

sum 2A*q=-2.044E+05

Vertical imbalance= -0.00

q @ mid spar= -269.20

FORM 362B-2

PREPARED BY a Cherritt	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A 44
CHECKED		TITLE 100 K.W. WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 3. MEAN LOADS

WINDMILL STA 187.5

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
2300	-7500	-1682500	130300	-1329100

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.22	-0.12	8.21E+09	1.91E+10	8.59E+03

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-30.80	-1.51	1030.43	28220.24	107.29
2	-1.82	-7.50	-17125.[illegible]	-9956.43	346.32
3	-3.10	-7.67	-44042.15	-15720.34	160.78
4	4.50	-6.12	-57807.16	-18121.37	-43.81
5	3.45	-4.26	-22074.98	-17553.98	-112.35
6	11.80	0.20	-13779.50	-8947.73	-138.79
7	9.46	4.77	4715.26	3773.01	-102.43
8	5.36	6.56	30168.60	11299.10	37.34
9	-1.60	7.73	58014.55	19638.18	260.74
10	-8.54	7.42	42049.10	24447.15	71.52
11	-30.80	-0.30	9949.85	31003.28	91.20

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	530.45	492.50
correction shear flow	182.38	22.34
Q due to torsion	240.45	68.86

MY @ shear center= 161468.10

sum 2A*q=-2.123E+05

Vertical imbalance= -0.00

q @ mid spar= -331.63

FORM 362B-2

CASE 3. MEAN LOADS.

WINDMILL STA 235.0

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
1770	-7435	-1660700	116100	-1009700

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.95	0.02	5.99E+09	1.68E+10	9.24E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-37.20	-1.50	7647.30	23897.80	117.85
2	-9.17	-6.74	-21486.80	-12492.32	366.44
3	-3.22	-6.92	-44865.52	-17525.59	156.48
4	4.19	-4.84	-54684.00	-17142.32	-62.39
5	9.15	-3.84	-22522.74	-18018.19	-143.15
6	11.39	0.05	-10609.91	-8487.92	-167.20
7	10.03	3.55	1985.59	2647.45	-146.58
8	6.23	5.44	32299.16	10986.11	24.15
9	-1.10	6.75	60984.86	20328.29	286.59
10	-7.99	6.46	42514.71	24717.86	83.60
11	-37.20	-0.32	8737.34	27304.18	103.12

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	439.20	410.51
correction shear flow	207.71	26.23
Q due to torsion	263.25	76.89

MY @ shear center= 147184.70

sum 2A*q=-2.012E+05

Vertical Imbalance= 0.00

q @ mid spar= -367.84

FORM 362B-2

CASE 3. MEAN LOADS.

WINDMILL STA 301

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
1200	-7100	-1328070	95600	-669950

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.69	-0.06	4.19E+09	1.32E+10	3.90E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-33.79	-1.17	5107.64	16476.26	107.33
2	-7.61	-5.61	-23212.99	-13495.93	395.02
3	-2.11	-5.72	-42176.15	-17144.77	162.56
4	4.19	-4.80	-48307.44	-17958.16	-73.26
5	8.12	-3.50	-16128.85	-16128.85	-144.30
6	10.63	-0.34	-8582.53	-7463.07	-168.13
7	9.03	3.22	4952.14	4952.14	-125.96
8	5.50	4.68	31648.84	11765.37	67.74
9	-1.13	5.72	52481.17	19084.06	340.10
10	-7.63	5.46	38082.95	22141.25	84.82
11	-33.79	-0.14	6135.20	19790.98	98.79

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	344.97	316.67
correction shear flow	249.58	25.75
Q due to torsion	282.93	73.04

MY @ shear center= 120730.27

sum 2A*q=-1.766E+05

Vertical imbalance= 0.00

q @ mid spar= -433.71

CASE 3. MEAN LOADS

WINDMILLSTA 389.0

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
710	-6250	-893200	78700	-372500

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.54	-0.13	2.28E+09	9.22E+09	2.52E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-29.34	-1.19	3090.06	10300.19	136.47
2	-6.24	-4.34	-24136.48	-14032.84	435.92
3	-1.84	-4.38	-29932.13	-16446.22	221.39
4	3.89	-3.61	-52086.12	-16327.94	-114.85
5	8.40	-2.13	-9575.98	-12767.97	-168.50
6	9.53	0.13	-2629.06	-4381.77	-175.12
7	8.18	2.40	3986.20	5314.93	-134.99
8	4.86	3.62	31773.69	11855.85	111.99
9	-0.68	4.46	40560.65	18026.95	390.37
10	-6.04	4.28	34502.43	20059.55	119.94
11	-29.34	-0.05	4446.75	14822.49	132.91

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	227.33	226.28
correction shear flow	267.76	32.42
Q due to torsion	353.91	100.50

MY @ shear center= 103195.98

sum 2A*q=-1.345E+05

Vertical imbalance= 0.00

q @ mid spar= -488.76

PREPARED BY	DATE	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE
A Cherritt	3/75		3.A.48
CHECKED		TITLE: 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 3. MEAN LOADS.

WINDMILL STA 477

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
405	-5010	-515000	49010	-178000

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.55	-0.03	1.05E+09	6.00E+09	1.27E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-25.35	-0.87	1584.07	5866 92	113.35
2	-4.32	-3.24	-24099.38	-14011.27	450.28
3	-0.80	-3.23	-26941.40	-15573.06	186.62
4	3.37	-2.39	-31689.65	-13314.98	-99.73
5	6.57	-1.92	-7251.84	-12086.40	-161.23
6	7.93	-0.05	-2406.83	-3438.32	-172.33
7	6.85	1.81	3069.19	6138.39	-135.12
8	4.30	2.57	25933.63	10896.49	138.23
9	-0.48	3.27	29580.92	16253.25	422.48
10	-4.74	3.13	29708.06	17272.13	103.75
11	-25.35	-0.17	2513.21	9308.18	113.04

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	134.82	145.39
correction shear flow	340.46	28.22
Q due to torsion	360.83	84.82

MY @ shear center= 60978.91

sum 2A*q=-8.837E+04

Vertical imbalance= 0.00

q @ mid spar= -588.25

FORM 362B-2

CASE 3. MEAN LOADS.

WINDMILL STA 365

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
200	-3495	-236200	28900	-64900

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.34	-0.00	4.29E+08	2.63E+09	2.83E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-22.01	-0.67	408.50	2917.37	101.62
2	-3.92	-2.28	-18111.17	-11390.67	454.33
3	-0.66	-2.22	-15766.94	-12035.83	219.15
4	3.25	-1.65	-22634.04	-10059.57	-94.36
5	5.66	-1.21	-3090.19	-3351.85	-134.07
6	6.43	-0.26	-934.30	-3336.80	-142.79
7	5.64	1.00	1928.64	3857.28	-106.36
8	2.94	1.81	20561.96	9138.65	215.87
9	-0.39	2.18	16150.87	12328.91	451.04
10	-3.94	2.15	20792.14	13076.81	102.71
11	-22.01	-0.30	694.53	4960.93	104.28

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	74.49	36.79
correction shear flow	363.35	22.72
Q due to torsion	378.56	81.55

MY @ shear center= 35276.60

sum 2A*q=-4.970E+04

Vertical imbalance= 0.00

q @ mid spar= -637.64

CASE 3. MEAN LOADS.

WINDMILLSTA 609

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
120	-2650	-137600	20290	-33400

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.92	-0.00	1.87E+08	1.56E+09	4.18E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-20.08	-0.78	354.33	2530.96	116.83
2	-1.62	-1.84	-20194.05	-12944.90	401.73
3	1.17	-1.85	-4959.31	-14169.46	308.08
4	2.57	-1.50	-9112.46	-12149.95	139.90
5	3.93	-1.20	-4927.91	-10484.91	51.64
6	5.01	-1.02	-1151.37	-9594.73	31.58
7	5.63	-0.16	-624.56	-3469.76	22.98
8	4.93	0.97	936.48	5202.69	43.87
9	3.62	1.39	4163.70	8858.94	129.29
10	2.30	1.73	8944.32	11925.76	306.37
11	1.10	1.99	3300.40	14349.57	370.44
12	-1.40	1.87	22604.47	14490.04	116.00
13	-20.08	-0.48	665.95	4756.76	119.40

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	43.68	74.33
correction shear flow	397.94	21.64
Q due to torsion	401.66	97.76

MY @ shear center= 24819.98

sum 2A*q=-2.772E+04

Vertical imbalance= 0.00

q @ mid spar= -680.20

CASE 3. MEAN LOADS

WINDMILL STA 653

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
50	-1810	-65140	12840	-14260

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.88	-0.01	5.08E+07	1.06E+09	1.72E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-17.96	-0.49	-25.86	-184.68	148.66
2	0.07	-1.51	-7342.53	-19580.09	-54.64
3	0.98	-1.44	-4937.07	-18988.73	471.81
4	2.20	-1.32	-7143.14	-17857.85	276.80
5	3.54	-1.16	-2031.41	-16251.25	221.97
6	4.46	-0.85	-1570.13	-12561.06	180.29
7	5.00	-0.07	-365.06	-2664.70	172.40
8	4.40	0.71	953.05	7624.36	200.59
9	3.49	1.20	1783.95	14271.63	251.42
10	2.25	1.44	7120.42	17801.04	451.59
11	0.98	1.57	5178.92	19918.91	-66.51
12	0.10	1.62	7825.63	20868.35	150.38
13	-17.96	-0.17	553.24	3951.68	157.54

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	18.25	67.74
correction shear flow	409.07	19.38
Q due to torsion	410.85	138.16

MY @ shear center= 16858.96

sum 2A*q=-1.124E+04

Vertical imbalance= -0.00

q @ mid spar= -662.38

PREPARED BY a Blewitt	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3 A.52
CHECKED		TITLE 100 KW. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 3. MEAN LOADS.

WINDMILL STA 697

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
0	-1160	-27400	8650	-5650

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.57	-0.03	2.74E+07	7.98E+08	1.17E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-15.54	-0.40	-92.92	-663.68	142.18
2	0.45	-1.17	-4473.28	-11928.76	-46.13
3	1.28	-1.05	-2833.96	-10899.84	415.05
4	2.27	-1.09	-2879.97	-11519.90	295.18
5	3.23	-0.92	-1251.88	-10015.05	243.55
6	4.15	-0.69	-789.62	-7896.21	211.46
7	4.63	-0.15	-255.40	-2554.04	202.06
8	4.15	0.53	551.29	4410.36	226.88
9	3.23	0.96	1118.65	8949.17	275.31
10	2.25	1.13	2719.60	10878.39	391.77
11	1.33	1.21	3090.52	11886.63	-56.54
12	0.45	1.28	4794.47	12785.25	146.33
13	-15.54	-0.12	302.51	2160.78	152.60

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	11.70	47.67
correction shear flow	347.75	17.92
Q due to torsion	384.64	134.68

MY @ shear center= 10921.73

sum 2A*q=-6.186E+03

Vertical imbalance= -0.00

q @ mid spar= -579.79

FORM 362B-2

CASE 4. MEAN LOADS.

WINDMILL STA 48.00

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
11420	-16580	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.60	0.22	1.88E+10	2.65E+10	2.20E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-40.16	-2.72	0.00	0.00	126.10
2	-7.08	-12.03	0.00	0.00	351.82
3	-0.65	-11.64	0.00	0.00	63.61
4	6.40	-8.90	0.00	0.00	-273.69
5	10.54	-5.15	0.00	0.00	-364.37
6	11.50	0.63	0.00	0.00	-434.71
7	9.62	6.33	0.00	0.00	-440.64
8	5.10	9.65	0.00	0.00	-233.05
9	-2.58	11.50	0.00	0.00	75.18
10	-8.51	10.96	0.00	0.00	-41.21
11	-40.16	-0.78	0.00	0.00	46.96

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	741.18	809.39
correction shear flow	400.08	41.33
Q due to torsion	14.49	5.63

MY @ shear center= 15291.98

sum 2A*q=-4.477E+05

Vertical imbalance= 0.00

q @ mid spar= -367.61

CASE 4. MEAN LOADS.

RIB REACT.@STA 81.50

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-9560	17680	0	-2950	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.02	-0.05	1.59E+10	2.93E+10	9.08E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.42	-2.43	0.00	0.00	-127.98
2	-7.68	-10.73	0.00	0.00	-320.99
3	-1.16	-10.69	0.00	0.00	17.70
4	6.12	-8.40	0.00	0.00	391.24
5	10.51	-5.23	0.00	0.00	488.27
6	12.06	0.15	0.00	0.00	568.00
7	10.58	5.55	0.00	0.00	543.30
8	6.10	8.93	0.00	0.00	281.55
9	-1.44	10.85	0.00	0.00	-70.34
10	-7.50	10.43	0.00	0.00	34.48
11	-39.42	-0.23	0.00	0.00	-54.72

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	697.73	743.30
correction shear flow	-358.21	-40.68
Q due to torsion	-50.78	-14.04

MY @ shear center= -45867.61

sum 2A*q= 4.807E+05

Vertical inbalance= 0.00

q @ mid spar= 354.27

PREPARED BY a [signature]	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.55
CHECKED		TITLE 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 4. MEAN LOADS.

WINDMILL STA 81.50

SX lb	SZ lb	MX In-lb	MY In-lb	MZ In-lb
-240	-90	-580400	2951	-323500

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.02	-0.05	1.59E+10	2.93E+10	9.08E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-39.42	-2.43	2487.95	3887.41	-0.98
2	-7.63	-10.73	-5254.04	-3054.67	1.01
3	-1.16	-10.69	-11113.23	-3832.17	-0.87
4	6.12	-8.40	[illegible]	-3665.73	[illegible]
5	10.51	-5.23	-3221.12	-3221.12	-0.13
6	12.06	0.15	-2693.01	-1409.95	1.72
7	10.58	5.55	776.89	776.89	2.86
8	6.10	8.93	8531.68	2577.55	6.01
9	-1.44	10.85	11570.51	4207.46	7.25
10	-7.50	10.43	8235.65	4787.82	3.15
11	-39.42	-0.23	3011.25	4705.07	1.12

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	697.73	743.30
correction shear flow	1.64	0.16
Q due to torsion	3.48	0.96

MY @ shear center= 3141.88

sum 2A*q=-2.260E+03

Vertical imbalance= -0.00

q @ mid spar= -4.00

FORM 362B-2

CASE 4. MEAN LOADS.

WINDMILL STA 125

SX lb	SZ lb	MX In-lb	MY In-lb	MZ In-lb
-215	-20	-502300	6780	-222400

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.85	-0.16	1.24E+10	2.75E+10	1.28E+09

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-38.97	-2.02	1807.95	3064.33	0.80
2	-8.53	-9.24	-5118.57	-2975.91	5.47
3	-2.05	-9.32	-10425.36	-3658.02	4.80
4	5.47	-7.60	-11797.96	-3698.42	5.97
5	10.28	-4.67	-3707.54	-2966.03	6.92
6	12.45	-0.20	-1783.71	-1331.12	8.21
7	11.20	4.56	958.07	766.46	9.35
8	6.52	7.86	8302.18	2602.57	11.17
9	-0.93	9.63	11633.98	4082.10	11.18
10	-7.35	9.26	7863.38	4571.73	4.39
11	-38.97	-0.14	2267.57	3843.34	2.60

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	632.44	630.93
correction shear flow	0.29	-0.00
Q due to torsion	8.25	2.60

MY @ shear center= 6858.13

sum 2A*q=-4.461E+02

Vertical imbalance= 0.00

q @ mid spar= -5.94

CASE 4. MEAN LOADS

WINDMILL STA 187.5

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-200	110	-380120	6000	-129380

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.22	-0.32	8.21E+09	1.91E+10	8.59E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.80	-1.51	840.55	2626.72	0.66
2	-9.82	-7.50	-4661.80	-2710.38	4.18
3	-3.10	-7.67	-9391.11	-3353.97	6.35
4	4.50	-6.12	-10401.40	-3269.63	10.77
5	9.45	-4.26	-3498.72	-2798.97	12.86
6	11.80	0.20	-1376.49	-893.82	14.82
7	0.46	4.77	1820.53	1456.42	15.27
8	5.36	6.56	7059.22	2643.95	14.30
9	-1.60	7.73	11336.86	3778.95	10.40
10	-8.54	7.42	7249.35	4214.74	3.40
11	-39.80	-0.30	1023.05	3197.04	2.00

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	530.45	492.59
correction shear flow	-2.72	-0.36
Q due to torsion	8.24	2.36

MY @ shear center= 5534.62

sum 2A*q= 3.164E+03

Vertical imbalance= 0.00

q @ mid spar= -3.52

FORM 362B-2

PREPARED BY	DATE	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE
A Cherritt	3/75		3.A.58
CHECKED		TITLE: 100 KW. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 4. MEAN LOADS.

WINDMILL STA 235.0

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-180	210	-290400	3490	-72800

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.95	0.02	5.99E+09	1.68E+10	9.24E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-37.20	-1.50	601.49	1879.67	-0.76
2	-9.17	-6.74	-4627.23	-2690.25	-0.38
3	-3.22	-6.92	-8188.49	-3198.63	5.12
4	4.19	-4.84	-8585.33	-2690.70	12.53
5	9.15	-3.84	-5181.21	-2544.97	15.76
6	11.39	0.05	-970.53	-776.43	17.54
7	10.03	3.55	789.48	1052.64	17.52
8	6.23	5.44	6633.65	2256.34	13.93
9	-1.10	6.75	10264.64	3421.55	6.02
10	-7.99	6.46	6473.06	3763.41	2.05
11	-37.20	-0.32	788.49	2464.02	0.58

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	439.20	410.51
correction shear flow	-5.94	-0.77
Q due to torsion	4.62	1.35

MY @ shear center= 2580.88

sum 2A*q= 5.759E+03

Vertical imbalance= -0.00

q @ mid spar= 1.90

FORM 362B-2

PREPARED BY	DATE	LOCKHEED-CALIFORNIA COMPANY	PAGE
A. Chentt	3/75	A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	3.A.59
CHECKED		TITLE 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 4. MEAN LOADS.

WINDMILL STA 301

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-145	325	-180880	2640	-30250

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.69	-0.06	4.19E+09	1.32E+10	3.90E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-33.79	-1.17	214.83	692.99	-1.39
2	-7.61	-5.61	-3722.93	-2164.49	-3.25
3	-2.11	-5.72	-5922.94	-2407.70	7.12
4	4.19	-4.80	-6004.86	-2232.29	18.77
5	8.12	-3.50	-1807.73	-1807.73	22.59
6	10.63	-0.34	-604.22	-525.41	24.52
7	9.03	3.22	1076.58	1076.58	23.18
8	5.50	4.68	4938.07	1835.71	15.24
9	-1.13	5.72	6937.48	2522.72	2.46
10	-7.63	5.46	4542.31	2640.88	1.06
11	-33.79	-0.14	353.41	1140.03	-0.29

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	344.97	316.67
correction shear flow	-11.49	-1.19
Q due to torsion	3.48	0.90

MY @ shear center= 1484.70

sum 2A*q= 8.116E+03

Vertical imbalance= -0.00

q @ mid spar= 7.72

FORM 362B-2

CASE 4. MEAN LOADS.

WINDMILL STA 389.0

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-115	510	-75300	1600	-11550

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.54	-0.13	2.28E+09	9.22E+09	2.52E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-29.34	-1.19	71.38	237.94	-3.88
2	-6.24	-4.34	-2248.57	-1307.31	-9.26
3	-1.84	-4.38	-2576.57	-1415.70	8.09
4	3.89	-3.61	-4095.60	-1283.89	36.37
5	8.40	-2.13	-667.47	-889.96	41.15
6	9.53	0.13	-98.39	-163.98	42.05
7	8.18	2.40	464.19	618.93	39.14
8	4.86	3.62	2936.68	1095.78	19.73
9	-0.68	4.46	3362.49	1494.44	-3.15
10	-6.04	4.28	2666.92	1550.53	-1.44
11	-29.34	-0.05	184.94	616.46	-3.04

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	227.33	226.28
correction shear flow	-21.89	-2.65
Q due to torsion	-1.37	-0.39

MY @ shear center= -400.31

sum 2A*q= 1.098E+04

Vertical imbalance= -0.00

q @ mid spar= 20.22

PREPARED BY	DATE	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE
A Christt	3/75		3.A.61
CHECKED		TITLE: 100 KW. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 4. MEAN LOADS.

WINDMILL STA 477

SX lb	SZ lb	MX In-lb	MY In-lb	MZ In-lb
-75	560	-16460	935	-5220

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.55	-0.03	1.05E+09	6.00E+09	1.27E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-25.35	-0.87	45.29	167.73	-4.10
2	-4.82	-3.24	-776.21	-451.29	-13.15
3	-0.30	-3.23	-861.63	-498.05	16.29
4	3.87	-2.39	-1005.08	-422.30	48.79
5	6.57	-1.92	-228.58	-380.96	55.86
6	7.93	-0.05	-72.57	-103.67	57.38
7	6.85	1.81	100.69	201.39	53.39
8	4.30	2.57	836.32	351.39	23.30
9	-0.48	3.27	944.20	513.79	-8.55
10	-4.74	3.13	942.61	548.03	-2.34
11	-25.35	-0.17	74.97	277.65	-3.72

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	134.82	145.39
correction shear flow	-38.09	-3.16
Q due to torsion	-2.40	-0.56

MY @ shear center= -405.00

sum 2A*q= 9.885E+03

Vertical imbalance= -0.00

q @ mid spar= 36.77

FORM 362B-2

CASE 4. MEAN LOADS.

WINDMILL STA 565

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-35	550	4150	420	-2735

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.84	-0.00	4.29E+08	2.68E+09	2.83E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-22.01	-0.67	37.16	265.44	-4.55
2	-3.92	-2.28	404.55	254.44	-18.31
3	-0.66	-2.22	286.65	218.82	18.69
4	3.25	-1.65	288.57	128.25	68.13
5	5.66	-1.21	23.65	63.91	74.40
6	6.43	-0.26	-9.63	-34.40	75.80
7	5.64	1.00	-74.10	-148.21	70.10
8	2.94	1.81	-452.91	-201.29	19.48
9	-0.39	2.18	-264.31	-201.76	-17.55
10	-3.94	2.15	-271.81	-170.95	-4.64
11	-22.01	-0.30	32.19	229.90	-4.93

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	74.49	86.79
correction shear flow	-57.18	-3.58
q due to torsion	-6.26	-1.35

MY @ shear center= -583.64

sum 2A*q= 7.823E+03

Vertical imbalance= -0.00

q @ mid spar= 58.52

CASE 4 MEAN LOADS

WINDMILL STA 609

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-20	370	5080	240	-1912

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.92	-0.00	1.87E+08	1.56E+09	4.18E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-20.08	-0.78	43.37	309.79	-4.26
2	-1.62	-1.84	783.95	502.53	-6.46
3	1.17	-1.85	171.92	491.20	6.63
4	2.57	-1.50	292.40	389.87	30.16
5	3.93	-1.20	142.04	302.21	42.52
6	5.01	-1.02	29.79	248.29	45.34
7	5.63	-0.16	2.43	13.48	46.56
8	4.93	0.97	-51.74	-287.42	43.66
9	3.62	1.39	-185.17	-393.98	31.76
10	2.30	1.73	-359.21	-478.94	7.07
11	1.10	1.99	-124.88	-542.95	-1.87
12	-1.40	1.87	-776.96	-498.05	-4.03
13	-20.08	-0.48	32.06	228.97	-4.57

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	43.68	74.33
correction shear flow	-55.57	-3.02
Q due to torsion	-6.34	-1.54

MY @ shear center= -391.52

sum 2A*q= 3.871E+03

Vertical imbalance= -0.00

q @ mid spar= 57.35

CASE 4. MEAN LOADS.

WINDMILL STA 653

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-10	270	3240	135	-1330

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.88	-0.01	5.08E+07	1.06E+09	1.72E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-17.96	-0.49	49.38	352.70	-5.43
2	0.07	-1.51	360.97	962.60	24.90
3	0.98	-1.44	238.18	916.07	-20.47
4	2.20	-1.32	334.82	837.05	8.64
5	3.54	-1.16	91.54	732.32	16.83
6	4.46	-0.85	66.63	533.04	23.07
7	5.00	-0.07	4.86	35.49	24.26
8	4.40	0.71	-57.45	-459.57	20.07
9	3.49	1.20	-96.18	-769.42	12.49
10	2.25	1.44	-367.78	-919.45	-17.35
11	0.98	1.57	-259.85	-999.42	26.79
12	0.10	1.62	-386.00	-1029.33	-5.57
13	-17.96	-0.17	20.87	149.06	-6.70

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	18.25	67.74
correction shear flow	-61.03	-2.89
Q due to torsion	-11.33	-3.81

MY @ shear center= -464.72

sum 2A*q= 1.677E+03

Vertical imbalance= 0.00

q @ mid spar= 65.66

CASE 4. MEAN LOADS.

WINDMILL STA 697

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
0	180	1500	150	-910

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.57	-0.03	2.74E+07	7.98E+08	1.17E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-15.54	-0.40	38.15	272.52	-3.66
2	0.45	-1.17	239.41	638.41	25.56
3	1.28	-1.05	148.23	570.12	-11.85
4	2.27	-1.09	147.15	588.58	6.75
5	3.23	-0.92	61.57	492.56	14.76
6	4.15	-0.69	36.39	363.94	19.74
7	4.63	-0.15	6.77	67.65	21.20
8	4.15	0.53	-37.72	-301.77	17.35
9	3.23	0.96	-66.66	-533.28	9.83
10	2.25	1.13	-155.68	-622.72	-8.24
11	1.33	1.21	-172.44	-663.25	27.17
12	0.45	1.28	-261.92	-698.46	-4.31
13	-15.54	-0.12	16.76	119.73	-5.28

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	11.70	47.67
correction shear flow	-53.96	-2.78
Q due to torsion	-7.13	-2.50

MY @ shear center= -202.51

sum 2A*q= 9.600E+02

Vertical imbalance= 0.00

q @ mid spar= 55.82

PREPARED BY	DATE	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE
O Elcock	3/75		3.A.66
CHECKED		TITLE: 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 1,2 & 4. CYCLIC LOADS.

WINDMILL STA 48.00

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
10680	6602	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.60	0.22	1.88E+10	2.65E+10	2.20E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-40.16	-2.72	0.00	0.00	73.23
2	-7.08	-12.03	0.00	0.00	77.37
3	-0.65	-11.64	0.00	0.00	202.74
4	6.40	-8.90	0.00	0.00	219.66
5	10.54	-5.15	0.00	0.00	195.22
6	11.50	0.63	0.00	0.00	95.36
7	9.62	6.33	0.00	0.00	35.08
8	5.10	9.65	0.00	0.00	-144.27
9	-2.58	11.50	0.00	0.00	-226.05
10	-8.51	10.96	0.00	0.00	-104.54
11	-40.16	-0.78	0.00	0.00	-17.45

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	741.18	809.39
correction shear flow	-142.22	-15.79
Q due to torsion	-4.27	-1.66

MY @ shear center= -4510.87

sum 2A*q= 1.635E+05

Vertical imbalance= 0.00

q @ mid spar= 129.05

FORM 362B-2

PREPARED BY a-ldor. df	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.67
CHECKED		TITLE 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 1,2 & 4. CYCLIC LOADS.

RIB REACT.@STA 81.50

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
12780	6520	0	-4100	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.02	-0.05	1.59E+10	2.93E+10	9.08E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.42	-2.43	0.00	0.00	94.73
2	-7.68	-10.73	0.00	0.00	97.28
3	-1.16	-10.69	0.00	0.00	231.00
4	6.12	-8.40	0.00	0.00	251.73
5	10.51	-5.23	0.00	0.00	227.45
6	12.06	0.15	0.00	0.00	128.92
7	10.58	5.55	0.00	0.00	62.77
8	6.10	8.93	0.00	0.00	-136.62
9	-1.44	10.85	0.00	0.00	-234.96
10	-7.50	10.43	0.00	0.00	-125.16
11	-39.42	-0.23	0.00	0.00	-17.93

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	697.73	743.30
correction shear flow	-121.98	-12.29
Q due to torsion	-20.40	-5.64

MY @ shear center= -18425.22

sum 2A*q= 1.667E+05

Vertical imbalance= 0.00

q @ mid spar= 124.45

FORM 362B-2

PREPARED BY a-blue?-ill?	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.68
CHECKED		TITLE 100 KW. WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 1,2 & 4. CYCLIC LOADS.

WINDMILL STA 81.50

SX lb	SZ lb	MX In-lb	MY In-lb	MZ In-lb
-1525	-960	-183500	4100	371400

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.02	-0.05	1.59E+10	2.93E+10	9.08E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-39.42	-2.43	-3271.18	-5111.22	-9.75
2	-7.68	-10.73	-3[illegible]22.[illegible]7	-2106.20	-5.66
3	-1.16	-10.69	-3769.84	-1299.95	-25.16
4	6.12	-8.40	-499.41	-150.55	-30.77
5	10.51	-5.23	726.68	726.68	-28.51
6	12.06	0.15	2864.89	1499.94	-16.80
7	10.58	5.55	1902.69	1902.69	-8.31
8	6.10	8.93	5685.61	1717.71	18.80
9	-1.44	10.85	2745.18	998.25	33.97
10	-7.50	10.43	356.76	207.42	16.50
11	-39.42	-0.23	-3118.71	-4[illegible]72.98	3.78

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	697.73	743.30
correction shear flow	18.[illegible]	1.87
Q due to torsion	6.91	1.91

MY @ shear center= 6242.09

sum 2A*q=-2.478E+04

Vertical Imbalance= 0.00

q @ mid spar= -21.31

FORM 362B-2

CASE 1,2 & 4. CYCLIC LOADS.

WINDMILL STA 125

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-1140	-473	-121740	2430	325900

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.85	-0.16	1.24E+10	2.75E+10	1.28E+09

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-38.97	-2.02	-2732.99	-4632.18	-6.87
2	-8.53	-9.24	-3047.16	-1771.61	-6.84
3	-2.05	-9.32	-2956.04	-1037.21	-18.18
4	5.47	-7.60	-92.03	-28.85	-19.46
5	10.28	-4.67	967.09	773.67	-16.32
6	12.45	-0.20	1885.10	1406.79	-9.77
7	11.20	4.56	2092.05	1673.64	-2.26
8	6.52	7.86	4537.45	1422.40	14.53
9	-0.93	9.63	2059.25	722.54	22.79
10	-7.35	9.26	-75.23	-43.74	11.88
11	-38.97	-0.14	-2637.48	-4470.31	2.70

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	632.44	630.93
correction shear flow	8.66	1.02
Q due to torsion	5.31	1.67

MY @ shear center= 4411.07

sum 2A*q=-1.250E+04

Vertical imbalance= 0.00

q @ mid spar= -11.27

PREPARED BY A. Hewitt	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.70
CHECKED		TITLE 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 1,2 & 4. CYCLIC LOADS.

WINDMILL STA 167.5

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-1150	-280	-62350	1900	257700

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.22	-0.12	8.21E+09	1.91E+10	8.59E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.80	-1.51	-1794.72	-5327.26	-5.39
2	-9.82	-7.50	-3029.66	-1761.08	-9.45
3	-3.10	-7.67	-2486.85	-883.16	-20.36
4	4.50	-6.12	554.65	208.36	-17.82
5	9.45	-4.26	1219.95	975.88	-12.69
6	11.20	0.22	2409.55	1564.65	-2.41
7	9.46	4.77	1929.55	1543.64	5.00
8	5.36	6.56	2981.36	1116.84	18.87
9	-1.69	7.73	325.99	275.10	22.73
10	-8.54	7.42	-1129.99	-656.26	9.05
11	-39.80	-9.30	-1680.43	-5251.39	1.89

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	530.45	492.50
correction shear flow	6.46	0.00
Q due to torsion	4.47	1.28

MY @ shear center= 5004.80

sum 2A*q=-7.560E+03

Vertical inbalance= 0.00

q @ mid spar= -9.05

CASE 1,2&4. CYCLIC LOADS.

WINDMILL STA 235.0

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-985	-190	-37400	1530	208300

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
9.95	0.02	5.99E+09	1.68E+10	9.24E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-37.20	-1.50	-1466.03	-4581.35	-5.42
2	-9.17	-6.74	-2420.88	-1407.49	-10.16
3	-3.22	-6.92	-1774.21	-693.05	-18.93
4	4.19	-4.84	948.43	297.31	-14.81
5	9.15	-3.84	1178.88	943.10	-9.35
6	11.39	0.05	1731.12	1384.90	-1.18
7	10.03	3.55	1029.48	1372.64	3.74
8	6.23	5.44	2922.00	993.88	17.89
9	-1.10	6.75	483.79	161.26	20.63
10	-7.99	6.46	-1183.03	-687.81	8.36
11	-37.20	-0.32	-1449.54	-4529.82	1.51

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	439.20	410.51
correction shear flow	4.74	0.43
Q due to torsion	3.72	1.09

MY @ shear center= 2077.61

sum 2A*q=-4.545E+03

Vertical imbalance= 0.00

q @ mid spar= -6.94

CASE 1,2 & 4. CYCLIC LOADS

WINDMILL STA 301

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-830	-110	-16430	1050	147150

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.69	-0.06	4.19E+09	1.32E+10	3.90E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-33.79	-1.17	-1162.12	-3748.76	-5.40
2	-7.61	-5.61	-1717.75	-998.69	-10.09
3	-2.11	-5.72	-977.04	-397.17	-16.18
4	4.19	-4.80	866.39	322.08	-11.84
5	8.12	-3.50	791.74	791.74	-7.53
6	10.63	-0.34	1332.88	1159.02	-0.04
7	9.03	3.22	1085.99	1085.99	6.21
8	5.50	4.68	1990.80	740.08	17.94
9	-1.13	5.72	113.27	41.19	19.23
10	-7.63	5.46	-1171.27	-680.97	7.65
11	-33.79	-0.14	-1152.89	-3719.00	1.16

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	344.97	316.67
correction shear flow	3.28	0.31
Q due to torsion	3.26	0.84

MY @ shear center= 1392.51

sum 2A*q=-2.459E+03

Vertical imbalance= 0.00

q @ mid spar= -5.38

CASE 1,2&4. CYCLIC LOADS.

WINDMILL STA 389.0

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-570	-40	-4700	575	83500

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.54	-0.13	2.28E+09	9.22E+09	2.52E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-29.34	-1.19	-797.84	-2659.47	-4.64
2	-6.24	-4.34	-1047.23	-608.86	-9.10
3	-1.84	-4.38	-386.44	-212.33	-12.02
4	3.89	-3.61	997.71	312.76	-5.62
5	8.40	-2.13	551.48	735.31	-1.91
6	9.53	0.13	516.72	861.19	1.61
7	8.18	2.40	572.59	763.45	5.58
8	4.86	3.62	1277.97	476.86	14.62
9	-0.68	4.46	-31.59	-14.04	14.76
10	-6.04	4.28	-859.14	-499.50	6.22
11	-29.34	-0.05	-794.22	-2647.39	0.81

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	227.33	226.28
correction shear flow	1.29	0.11
Q due to torsion	2.46	0.70

MY @ shear center= 717.26

sum 2A*q=-7.274E+02

Vertical imbalance= -0.00

q @ mid spar= -2.93

PREPARED BY J Ehn.tb	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.74
CHECKED		TITLE 100 KW. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 1,2 & 4. CYCLIC LOADS.

WINDMILL STA 477

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-360	-15	-735	270	39400

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.55	-0.03	1.05E+09	6.00E+09	1.27E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-25.35	-0.87	-449.20	-1663.71	-3.69
2	-4.82	-3.24	-538.92	-313.32	-7.23
3	-0.80	-3.23	-85.38	-49.35	-8.44
4	3.87	-2.39	610.52	256.52	-3.33
5	6.57	-1.92	260.03	433.38	-1.05
6	7.93	-0.05	364.64	520.92	2.27
7	6.85	1.81	224.12	448.24	4.33
8	4.30	2.57	666.56	280.07	10.94
9	-0.48	3.27	-62.76	-34.48	10.83
10	-4.74	3.13	-540.24	-314.09	4.52
11	-25.35	-0.17	-449.38	-1664.38	0.42

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	134.82	145.39
correction shear flow	0.58	0.03
Q due to torsion	1.65	0.39

MY @ shear center= 279.62

sum 2A*q=-1.708E+02

Vertical imbalance= -0.00

q @ mid spar= -1.82

FORM 362B-2

CASE 1,2&4. CYCLIC LOADS

WINDMILL STA 565

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-185	-5	120	105	14130

LOAD CASE #A

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.84	-0.00	4.29E+08	2.68E+09	2.83E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-22.01	-0.67	-161.50	-1153.57	-1.87
2	-3.92	-2.28	-304.89	-191.75	-5.27
3	-0.66	-2.22	-27.01	-20.62	-6.07
4	3.25	-1.65	408.41	181.52	-1.30
5	5.66	-1.21	113.05	305.55	0.11
6	6.43	-0.26	95.23	340.10	1.34
7	5.64	1.00	145.32	290.64	3.32
8	2.94	1.81	322.92	143.52	8.16
9	-0.89	2.18	-78.99	-60.30	7.57
10	-3.94	2.15	-350.71	-220.57	2.38
11	-22.01	-0.30	-161.82	-1155.89	0.26

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	74.49	86.79
correction shear flow	0.26	0.01
Q due to torsion	1.13	0.24

MY @ shear center= 105.41

sum 2A*q=-4.108E+01

Vertical imbalance= 0.00

q @ mid spar= -1.13

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CHECKED		TITLE 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 1, 2 & 4. CYCLIC LOADS.

WINDMILL STA 609

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-70	0	140	60	7410

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.92	-0.00	1.87E+08	1.56E+09	4.18E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-20.08	-0.78	-132.76	-948.26	-1.07
2	-1.62	-1.84	-69.55	-44.58	-1.49
3	1.17	-1.85	31.25	89.27	-1.24
4	2.57	-1.50	112.51	150.01	-0.26
5	3.93	-1.20	98.57	209.73	0.63
6	5.01	-1.02	50.99	255.22	0.91
7	5.63	-0.16	49.02	272.34	1.37
8	4.93	0.97	39.30	218.32	1.75
9	3.62	1.39	69.53	147.94	2.45
10	2.30	1.73	58.90	78.53	3.10
11	1.10	1.99	3.76	16.33	3.17
12	-1.40	1.87	-157.99	-101.28	1.45
13	-20.08	-0.48	-133.52	-953.70	0.19

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	43.68	74.33
correction shear flow	-0.25	-0.02
Q due to torsion	0.87	0.21

MY @ shear center= 53.76

sum 2A*q= 1.881E+01

Vertical inbalance= -0.00

q @ mid spar= -0.44

FORM 362B-2

CASE 1 2,&4. CYCLIC LOADS.

WINDMILL STA 653

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-65	0	90	0	3350

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.88	-0.01	5.08E+07	1.06E+09	1.72E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-17.96	-0.49	-78.50	-560.73	-1.59
2	0.07	-1.51	17.06	45.50	-1.46
3	0.98	-1.44	18.88	72.63	-1.53
4	2.20	-1.32	43.30	108.25	-0.88
5	3.54	-1.16	18.32	146.57	-0.57
6	4.46	-0.85	20.90	167.16	-0.21
7	5.00	-0.07	22.22	162.17	0.22
8	4.40	0.71	15.08	120.68	0.54
9	3.49	1.20	9.69	77.55	0.77
10	2.25	1.44	12.40	31.01	1.21
11	0.98	1.57	-3.47	-13.36	1.59
12	0.10	1.62	-16.11	-42.95	1.48
13	-17.96	-0.17	-79.78	-569.88	-0.06

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	18.25	67.74
correction shear flow	-0.24	-0.01
Q due to torsion	-0.13	-0.04

MY @ shear center= -5.39

sum 2A*q= 1.067E+01

Vertical imbalance= 0.00

q @ mid spar= 0.31

CASE 1 2&4 CYCLIC LOADS.

WINDMILL STA 697

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-40	0	50	0	1430

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.57	-0.03	2.74E+07	7.98E+08	1.17E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-15.54	-0.40	-38.33	-273.79	-1.12
2	0.45	-1.17	14.55	38.79	-0.94
3	1.28	-1.05	13.22	50.85	-0.94
4	2.27	-1.09	17.50	70.00	-0.60
5	3.23	-0.92	10.39	83.14	-0.37
6	4.15	-0.69	9.40	93.97	-0.15
7	4.63	-0.15	8.87	88.69	0.09
8	4.15	0.53	7.77	62.19	0.34
9	3.23	0.96	4.27	34.16	0.52
10	2.25	1.13	2.95	11.80	0.74
11	1.33	1.21	-1.85	-7.11	1.08
12	0.45	1.28	-9.39	25.04	1.06
13	-15.54	-0.12	-39.35	-281.08	-0.03

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	11.70	47.67
correction shear flow	-0.22	-0.02
Q due to torsion	-0.05	-0.02

MY @ shear center= -1.43

sum 2A*q= 4.778E+00

Vertical imbalance= 0.00

q @ mid spar= 0.23

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APPROVED			REPORT NO. 27153

CASE 3. CYCLIC LOADS.

WINDMILL STA 48.00

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-6962	11170	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.60	0.22	1.88E+10	2.65E+10	2.20E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-40.16	-2.72	0.00	0.00	-79.03
2	-7.08	-12.03	0.00	0.00	-226.58
3	-0.65	-11.64	0.00	0.00	-31.90
4	6.40	-3.90	0.00	0.00	139.71
5	10.54	-5.15	0.00	0.00	247.88
6	11.50	0.63	0.00	0.00	302.25
7	9.62	6.33	0.00	0.00	290.11
8	5.10	9.65	0.00	0.00	145.61
9	-2.58	11.50	0.00	0.00	-60.07
10	-8.51	10.96	0.00	0.00	21.95
11	-40.16	-0.78	0.00	0.00	-31.58

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	741.18	809.39
correction shear flow	-268.71	-27.81
Q due to torsion	-9.69	-3.76

MY @ shear center= -10226.42

sum 2A*q= 3.009E+05

Vertical imbalance= -0.00

q @ mid spar= 246.83

FORM 362B-2

PREPARED BY a Abbott	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.80
CHECKED		TITLE 100 K.W. WINDMILL BLADE.	MODEL CL1708.
APPROVED			REPORT NO. 27153

CASE 3. CYCLIC LOADS.

RIB REACT.@STA 81.50

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-6650	13530	0	-10250	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.02	-0.05	1.59E+10	2.93E+10	9.08E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.42	-2.43	0.00	0.00	-94.55
2	-7.68	-10.73	0.00	0.00	-245.55
3	-1.16	-10.69	0.00	0.00	14.00
4	6.12	-8.40	0.00	0.00	295.03
5	10.51	-5.23	0.00	0.00	366.88
6	12.06	0.15	0.00	0.00	422.67
7	10.38	5.55	0.00	0.00	401.44
8	6.10	8.93	0.00	0.00	196.93
9	-1.44	10.85	0.00	0.00	-71.08
10	-7.50	10.43	0.00	0.00	18.35
11	-39.42	-0.23	0.00	0.00	-44.19

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	697.73	743.30
correction shear flow	-273.72	-31.02
Q due to torsion	-47.64	-13.17

MY @ shear center= -43032.28

sum 2A*q= 3.675E+05

Vertical inbalance= -0.00

q @ mid spar= 277.17

FORM 362B-2

CASE 3. CYCLIC.

WINDMILL STA 81.50

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
780	-1750	-388700	10250	-193800

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.02	-0.05	1.59E+10	2.93E+10	9.08E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.42	-2.43	1470.45	2297.57	14.26
2	-7.68	-10.73	-3613.32	-2100.76	40.56
3	-1.16	-10.69	-7455.05	-2570.71	6.95
4	6.12	-8.40	-8094.78	-2537.55	-28.83
5	10.51	-5.23	-2073.03	-2073.03	-37.82
6	12.06	0.15	-1624.25	-850.39	-44.41
7	10.58	5.55	600.23	600.23	-41.38
8	6.10	8.93	5857.92	1769.76	-14.43
9	-1.44	10.85	7704.85	2801.76	20.08
10	-7.50	10.43	5406.71	3143.43	1.03
11	-39.42	-0.23	1820.28	2844.19	8.43

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	697.73	743.30
correction shear flow	35.35	4.00
Q due to torsion	16.03	4.43

MY @ shear center= 14482.75

sum 2A*q=-4.748E+04

Vertical imbalance= 0.00

q @ mid spar= -42.96

CASE 3. CYCLIC LOADS

WINDMILL STA 125

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
540	-1450	-339700	11100	-129400

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.85	-0.16	1.24E+10	2.75E+10	1.28E+09

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-38.97	-2.02	1047.30	1775.09	15.15
2	-8.53	-9.24	-3561.56	-2070.67	38.34
3	-2.05	-9.32	-7074.30	-2482.21	8.13
4	5.47	-7.60	-7825.77	-2453.22	-25.19
5	10.28	-4.67	-2404.18	-1923.34	-35.39
6	12.45	-0.20	-1078.13	-804.57	-39.92
7	11.20	4.56	750.80	600.64	-36.65
8	6.52	7.86	5754.35	1803.87	-12.01
9	-0.93	9.63	7825.88	2745.92	21.37
10	-7.35	9.26	5208.35	3028.11	5.09
11	-38.97	-0.14	1357.26	2300.44	10.78

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	632.44	630.93
correction shear flow	28.41	4.21
Q due to torsion	20.82	6.56

MY @ shear center= 17309.29

sum 2A*q=-4.033E+04

vertical imbalance= 0.00

q @ mid spar= -38.45

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CHECKED		TITLE 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 3. CYCLIC LOADS.

WINDMILL STA 137.5

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
325	-1340	-266620	8450	-67890

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
1.22	-0.12	8.21E+09	1.91E+10	8.59E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-39.80	-1.51	479.68	1499.00	12.26
2	-9.82	-7.59	-3404.47	-1973.34	38.50
3	-3.10	-7.07	-6642.69	-2372.39	5.06
4	4.50	-6.12	-7153.53	-2242.49	-30.75
5	9.45	-4.26	-2346.35	-1877.48	-42.44
6	11.89	0.20	-808.30	-524.87	-46.35
7	9.46	4.77	1374.00	1039.20	-39.35
8	5.36	6.56	5059.57	1894.97	-13.81
9	-1.60	7.73	[illegible]	[illegible].75	25.78
10	-8.54	7.42	4945.99	2875.58	7.01
11	-39.80	-0.39	607.34	1837.94	9.96

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	530.45	402.59
correction shear flow	32.56	3.99
q due to torsion	20.88	5.98

MY @ shear center= 14024.44

sum 2A*q=-3.791E+04

Vertical imbalance= 0.00

q @ mid spar= -43.49

FORM 362B-2

PREPARED BY a Schmitt	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3 A 84
CHECKED		TITLE: 100 K.W. WINDMILL BLADE.	MODEL CL1708
APPROVED			REPORT NO 27153

CASE 3. CYCLIC LOADS.

WINDMILL STA 235.0

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
220	-1230	-214100	6600	-41950

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.95	0.02	5.99E+09	1.68E+10	9.24E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-37.20	-1.50	360.34	1126.05	12.37
2	-9.17	-6.74	-3509.75	-2040.55	36.87
3	-3.22	-6.92	-6075.79	-2373.36	1.90
4	4.19	-4.84	-6217.53	-1949.07	-33.62
5	9.15	-3.84	-2259.83	-1807.86	-46.45
6	11.39	0.05	-615.58	-492.46	-49.81
7	10.03	3.55	632.02	842.69	-46.09
8	6.23	5.44	5002.07	1701.38	-17.15
9	-1.10	6.75	7522.56	2507.52	25.98
10	-7.99	6.46	4663.72	2711.46	7.74
11	-37.20	-0.32	497.79	1555.59	10.45

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	439.20	410.51
correction shear flow	34.32	4.32
Q due to torsion	20.97	6.13

MY @ shear center= 11725.02

sum 2A*q=-3.325E+04

Vertical inbalance= 0.00

q @ mid spar= -44.85

FORM 362B-2

CASE 3. CYCLIC LOADS.

WINDMILL STA 301

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
105	-1060	-149590	4440	-19070

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.69	-0.06	4.19E+09	1.32E+10	3.90E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-33.79	-1.17	130.78	421.88	9.48
2	-7.61	-5.61	-3133.64	-1821.88	34.60
3	-2.11	-5.72	-4915.76	-1998.28	-0.32
4	4.19	-4.80	-4910.08	-1825.31	-34.83
5	8.12	-3.50	-1457.09	-1457.09	-44.96
6	10.63	-0.34	-444.64	-386.64	-47.83
7	9.03	3.22	929.55	929.55	-41.05
8	5.50	4.68	4145.03	1540.90	-11.36
9	-1.13	5.72	5716.88	2078.86	29.04
10	-7.63	5.46	3693.71	2147.50	7.29
11	-33.79	-0.14	245.26	791.16	8.79

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	344.97	316.67
correction shear flow	37.21	3.84
Q due to torsion	19.19	4.95

MY @ shear center= 8187.75

sum 2A*q=-2.635E+04

Vertical imbalance= 0.00

q @ mid spar= -47.61

CASE 3. CYCLIC LOADS.

WINDMILL STA 389.0

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
40	-750	-83500	3044	-6220

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.54	-0.13	2.28E+09	9.22E+09	2.52E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-29.34	-1.19	16.40	54.66	9.70
2	-6.24	-4.34	-2564.37	-1490.91	29.41
3	-1.84	-4.38	-2874.80	-1579.56	3.54
4	3.89	-3.61	-4443.57	-1392.97	-36.13
5	8.40	-2.13	-693.76	-925.01	-42.25
6	9.53	0.13	-68.20	-113.67	-42.77
7	8.18	2.40	557.27	743.02	-37.66
8	4.86	3.62	3342.11	1247.05	-7.44
9	-0.68	4.46	3709.77	1648.79	25.84
10	-6.04	4.28	2877.12	1672.74	8.58
11	-29.34	-0.05	142.05	473.50	9.71

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	227.33	226.28
correction shear flow	32.10	3.88
Q due to torsion	20.52	5.83

MY @ shear center= 5982.38

sum 2A*q=-1.613E+04

Vertical imbalance= 0.00

q @ mid spar= -42.91

CASE 3 CYCLIC LOADS.

WINDMILL STA 477

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
10	-515	-36600	1310	-1460

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.35	-0.03	1.05E+09	6.00E+09	1.27E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-25.35	-0.87	-14.82	-54.90	6.10
2	-4.82	-3.24	-1855.07	-1078.53	23.41
3	-0.80	-3.23	-1927.91	-1114.40	-3.73
4	3.87	-2.39	-2067.07	-868.52	-32.64
5	6.57	-1.92	-439.08	-731.79	-38.75
6	7.93	-0.05	-67.18	-95.97	-39.59
7	6.85	1.31	280.13	560.26	-35.59
8	4.30	2.57	2020.71	849.04	-6.99
9	-0.48	3.27	2072.63	1138.31	22.14
10	-4.74	3.13	1946.88	1131.90	5.83
11	-25.35	-0.17	50.78	188.09	6.43

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	134.82	145.39
correction shear flow	34.96	2.90
Q due to torsion	15.02	3.53

MY @ shear center= 2538.04

sum 2A*q=-9.076E+03

Vertical imbalance= 0.00

q @ mid spar= -43.55

PREPARED BY a Blevitt	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3.A.88
CHECKED		TITLE 100 KW. WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 3. CYCLIC LOADS.

WINDMILL STA 565

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
5	-475	-13450	560	-140

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.84	-0.00	4.29E+08	2.68E+09	2.83E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-22.01	-0.67	-17.42	-124.43	5.77
2	-3.92	-2.28	-1110.53	-698.45	24.82
3	-0.66	-2.22	-906.65	-692.10	-7.20
4	3.25	-1.65	-1188.75	-528.33	-49.19
5	5.66	-1.21	-147.85	-399.59	-54.41
6	6.43	-0.26	-29.30	-104.65	-55.44
7	5.64	1.00	146.72	293.45	-50.26
8	2.94	1.81	1254.95	557.75	-5.94
9	-0.89	2.18	901.83	688.42	25.91
10	-3.94	2.15	1098.18	690.68	6.42
11	-22.01	-0.30	-1.18	-8.42	6.38

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	74.49	86.79
correction shear flow	49.35	3.09
Q due to torsion	15.30	3.30

MY @ shear center= 1425.59

sum 2A*q=-6.752E+03

Vertical inbalance= 0.00

q @ mid spar= -58.27

FORM 362B-2

CASE 3. CYCLIC LOADS.

WINDMILL STA 609

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
0	-175	-6950	190	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.92	-0.00	1.87E+08	1.56E+09	4.18E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-20.08	-0.78	-12.38	-88.45	3.94
2	-1.62	-1.84	-1040.58	-667.04	7.64
3	1.17	-1.85	-244.50	-698.56	1.48
4	2.57	-1.50	-436.65	-582.20	-9.52
5	3.93	-1.20	-227.50	-484.05	-15.24
6	5.01	-1.02	-51.34	-427.79	-16.54
7	5.63	-0.16	-20.48	-113.77	-17.05
8	4.93	0.97	56.51	313.92	-15.63
9	3.62	1.39	227.17	483.35	-9.91
10	2.30	1.73	467.52	623.09	1.86
11	1.10	1.99	166.33	731.85	6.10
12	-1.40	1.87	1110.85	712.08	3.27
13	-20.08	-0.48	3.25	23.24	3.35

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	43.68	74.33
correction shear flow	26.25	1.43
Q due to torsion	7.90	1.92

MY @ shear center= 487.85

sum 2A*q=-1.828E+03

Vertical inbalance= 0.00

q @ mid spar= -30.89

PREPARED BY a Chevritt	DATE 3/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3 A 90
CHECKED		TITLE 100 K.W. WINDMILL BLADE.	MODEL CL 1708
APPROVED			REPORT NO. 27153

CASE 3. CYCLIC LOADS.

WINDMILL STA 653

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
0	-110	-3080	120	-30

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.88	-0.01	5.08E+07	1.06E+09	1.72E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-17.96	-0.49	-16.42	-117 26	3.55
2	0.07	-1.51	-345.84	-922.23	-8.80
3	0.98	-1.44	-231.10	-888.86	12.51
4	2.20	-1.32	-331.28	-828.20	0.69
5	3.54	-1.16	-93.05	-744.39	-2.63
6	4.46	-0.85	-70.62	-564.94	-5.15
7	5.00	-0.07	-13.06	-95.34	-5.60
8	4.40	0.71	48.24	385.88	-3.88
9	3.49	1.20	86.70	693.62	-0.78
10	2.25	1.44	340.98	852.44	11.41
11	0.98	1.57	245.59	944.56	-9.38
12	0.10	1.62	368.99	983.98	3.80
13	-17.96	-0.17	10.87	77.66	4.16

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	18.25	67.74
correction shear flow	24.85	1.18
Q due to torsion	8.87	2.98

MY @ shear center= 363.99

sum 2A*q=-6.827E+02

Vertical imbalance= -0.00

q @ mid spar= -29.56

FORM 362B-2

CASE 3 CYCLIC LOADS

WINDMILL STA 697

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
0	-60	-1290	10	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
0.57	-0.03	2.74E+07	7.98E+08	1.17E+07

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-15.54	-0.40	-11.59	-82.77	1.96
2	0.45	-1.17	-209.41	-558.42	-7.78
3	1.28	-1.05	-131.92	-507.37	6.06
4	2.27	-1.09	-133.30	-533.18	-0.14
5	3.23	-0.92	-57.42	-459.36	-2.81
6	4.15	-0.69	-35.68	-356.85	-4.47
7	4.63	-0.15	-10.45	-104.50	-4.95
8	4.15	0.53	27.60	220.80	-3.67
9	3.23	0.96	53.85	430.79	-1.16
10	2.25	1.13	129.52	518.09	4.86
11	1.33	1.21	146.21	562.36	-8.32
12	0.45	1.28	225.61	601.61	2.17
13	-15.54	-0.12	6.97	49.80	2.50

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	11.70	47.67
correction shear flow	17.99	0.93
Q due to torsion	4.49	1.57

MY @ shear center= 127.50

sum 2A*q=-3.200E+02

Vertical imbalance= -0.00

q @ mid spar= -19.98

PREPARED BY a Elderrath	DATE 6/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3 A.92
CHECKED		TITLE 100 KW. WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

BLADE SECTION PROPERTIES (FATIGUE PROPERTIES)

FATIGUE @ STA 187.5

INPUT DATA

GRID PT	X In	Z In	A In2	T In
1	-38.58	-1.63	0.32	0.04
2	-29.80	-4.25	0.53	0.04
3	-16.80	-6.95	0.53	0.04
4	-8.60	-7.62	1.72	0.25
5	-1.88	-7.79	2.80	0.25
6	5.72	-6.24	3.19	0.25
7	10.67	-4.38	1.25	0.25
8	13.02	0.08	1.54	0.25
9	10.68	4.65	1.25	0.25
10	6.56	6.44	2.67	0.25
11	-0.38	7.61	3.00	0.25
12	-7.32	7.30	1.72	0.04
13	-15.90	6.30	0.57	0.04
14	-29.90	2.70	0.57	0.04
15	-38.58	-0.42	0.32	0.08
			Σ 21.98	

XLA In	ZLA In	XMS In	ZMS In	HMS In	TMS In	G	E
1.83	0.00	-7.96	0.00	15.92	0.08	4.00E+06	1.00E+07

SX lb	SZ lb	MX In-lb	MY In-lb	MZ In-lb
0	10	0	0	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
-1.22	-0.15	8.83E+09	3.18E+10	1.04E+09

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q In-lb
1	-37.36	-1.48	0.00	0.00	-0.07
2	-28.58	-4.10	0.00	0.00	-0.05
3	-15.58	-6.80	0.00	0.00	-0.01
4	-7.38	-7.47	0.00	0.00	-0.12
5	-0.66	-7.64	0.00	0.00	0.12
6	6.94	-6.09	-0.00	0.00	0.35
7	11.89	-4.23	0.00	0.00	0.42
8	14.24	0.23	0.00	0.00	0.42
9	11.90	4.80	0.00	0.00	0.36
10	7.78	6.59	0.00	0.00	0.17
11	0.84	7.76	0.00	0.00	-0.10
12	-6.10	7.45	0.00	0.00	0.00
13	-14.68	6.45	0.00	0.00	-0.04
14	-28.68	2.85	0.00	0.00	-0.07
15	-37.36	-0.27	0.00	0.00	-0.07

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	530.39	579.38
correction shear flow	-0.27	-0.06
0 due to torsion	-0.05	-0.02

LATERAL LOCATION OF SHEAR CENTER AHEAD OF MID SPAR= 13.33 ✓

FORM 362B-2

CASE I. MEAN LOADS (FATIGUE PROPERTIES)

FATIGUE @ STA 187.5

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-450	2800	261600	-1190	-58270

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
-1.22	-0.15	8.83E+09	3.18E+10	1.04E+09

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-37.36	-1.48	242.74	758.55	-22.07
2	-28.58	-4.10	771.77	1456.16	-18.85
3	-15.58	-6.80	1134.79	2141.11	-9.35
4	-7.38	-7.47	3901.51	2268.32	-42.46
5	-0.66	-7.64	6330.02	2260.72	25.52
6	6.94	-6.09	5544.34	1738.04	93.12
7	11.39	-4.23	1433.32	1146.66	113.70
8	14.24	0.23	-291.90	-189.55	117.97
9	11.90	4.80	-1897.38	-1517.90	102.45
10	7.78	6.59	-5368.46	-2010.66	51.31
11	0.84	7.76	-6888.72	-2296.24	-22.51
12	-6.10	7.45	-3689.60	-2145.11	5.04
13	-14.68	6.45	-1012.49	-1776.30	-8.77
14	-28.68	2.85	-338.41	-593.71	-17.99
15	-37.36	-0.27	128.49	401.52	-20.65

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	530.39	579.38
correction shear flow	-76.15	-15.77
Q due to torsion	-15.60	-4.88

MY @ shear center= -11100.75

sum 2A*q= 8.684E+04

Vertical imbalance= 0.00

q @ mid spar= 71.10

CASE I. CYCLIC LOADS (FATIGUE PROPERTIES)

FATIGUE @ STA 187.5

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-1100	-280	-62850	1900	257700

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
-1.22	-0.15	3.83E+09	3.18E+10	1.04E+09

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-37.36	-1.48	-971.27	-3035.21	-1.87
2	-28.58	-4.10	-1327.87	-2505.41	-7.56
3	-15.58	-6.80	-873.48	-1648.07	-11.33
4	-7.38	-7.47	-1794.70	-1043.43	-10.53
5	-0.66	-7.64	-1468.58	-524.49	-17.08
6	6.94	-6.09	542.59	170.09	-15.03
7	11.89	-4.23	843.81	675.05	-11.51
8	14.24	0.23	1749.23	1135.87	-4.05
9	11.90	4.80	1542.47	1233.97	2.61
10	7.78	6.59	2723.43	1020.01	14.46
11	0.84	7.76	1636.65	545.55	21.76
12	-6.10	7.45	-35.07	-20.39	13.15
13	-14.68	6.45	-432.17	-758.19	11.36
14	-28.68	2.85	-1187.72	-2083.71	6.32
15	-37.36	-0.27	-947.34	-2960.42	2.28

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	530.39	579.38
correction shear flow	6.88	1.02
Q due to torsion	4.02	1.26

MY @ shear center= 2864.71

sum 2A*q=-7.947E+03

Vertical imbalance= 0.00

q @ mid spar= -8.63

PREPARED BY a Barrett	DATE 6/75	LOCKHEED-CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	PAGE 3 A.95
CHECKED		TITLE 100 KW. WINDMILL BLADE	MODEL CL1708
APPROVED			REPORT NO. 27153

CASE 3 MEAN + CYCLIC LOADS

STA 81.5 RIB REAC

SX lb	SZ lb	MX in-lb	MY in-lb	MZ in-lb
-82660	84620	0	-168150	0

CALCULATED DATA

XBAR	ZBAR	EIxx	EIzz	EIxz
-1.17	0.15	1.66E+10	4.23E+10	4.33E+08

GRID PT	X-XBAR	Z-ZBAR	LOAD	STRESS	q in-lb
1	-37.23	-2.63	0.00	0.00	-787.83
2	-29.33	-5.81	0.00	0.00	-964.54
3	-14.51	-10.03	0.00	0.00	-964.32
4	-5.49	-10.93	0.00	0.00	-2149.71
5	1.03	-10.89	0.00	0.00	-471.56
6	8.31	-8.60	0.00	0.00	1465.02
7	12.70	-5.43	0.00	0.00	1997.51
8	14.25	-0.05	0.00	0.00	2547.14
9	12.77	5.35	0.00	0.00	2528.46
10	8.29	8.73	0.00	0.00	1596.21
11	0.75	10.65	0.00	0.00	135.81
12	-5.31	10.23	0.00	0.00	1010.35
13	-14.51	8.69	0.00	0.00	546.56
14	-29.33	3.41	0.00	0.00	66.31
15	-37.23	-0.43	0.00	0.00	-396.85

SUPPLEMENTAL DATA

	CELL 1 front	CELL 2 rear
2A=	697.73	867.50
correction shear flow	*******	-408.40
Q due to torsion	27.67	11.56

MY @ shear center= 29334.69

sum 2A*q= 2.575E+06

Vertical imbalance= 0.00

q @ mid spar= 1959.66

FORM 362B-2

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